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

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
Bacheler of Science

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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.

CONTENTS

SPENCER, WHITE & PRENTIS

ESTIMATE NO. _____

SHEET NO. _____

DATE _____

JOB Detroit Ventilation Bldg., ARCHITECT May 27, 1931

MADE BY R.J. Wicheal FOR Thesis

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT	REF.
Excavation	Steam Shovel	2000	yds	$1.27	$2540	
	Clam "	2545	"	1.51	3850	
	Wells	322	"	11.60	3770	
	Trenches	478	"	9.69	4550	
Concrete		416	"			
				7.75	8360	
Forms	Walls	22700	Sq. Ft.	.20	4540	
	Lower forms	2763	" "	.23½	652	
	Curved forms	4970	" "	.37½	1850	
	Struts & elev. shafts	1387	" "	.37½	512	
Water proof	Sub-contract				1990	
Electrical	" "				2291	
Str. Steel	Erection only	73	Tons	20.00	1960	
	Louvres, panels, hatches, etc. (erection only)				320	
Rein. Steel		5022	"	.5000	2511	
	Placing	5022	"	.2000	1004	
Bracing	12"x12" - total cost	720	M	8000	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	$49516	

QUANTITIES

Excavation			
Steam Shovel			2,000 yds.
Clam Shovel			2,545
Wells	Included in clam excavation	(522	
		(	
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			1,387
			31,820 sq. ft.
Reinforcing Steel			50.22 tons
Structural Steel			73.0 tons
Concrete Finish			
Duets, top and bottom			858 sq. ft.
Walls and Floor			15,200
		Total	16,058 sq. ft.

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
5	Laborers at $4	12.00
	Insurance at 7% (Workmans Comp.)	2.10
		$328.

Unit Cost

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

2000 yds. at 1.27 = $2,540

Note:

The unit cost given is too low due to the hold-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.

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	8.00
		$275.00

Unit Cost

Shovel at 250 yds./day = $\frac{275}{25}$	$1.10
Dump charge	.25
Runways	.05
Trim[1]	.10
Insurance	.01
	$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.)

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

CAISSON EXCAVATION

(By Method of Chicago Open Wells[1])

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%	9.31
	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, Boots, Misc.	.30
	$11.60[3]

322 yds at $11.60 = $ 3,740

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

[2]2" x 6" x 6' finished (one side) matched maple.

[3]This 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.

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%	18.00
		$280.00

Unit Cost

Labor 280/45	$ 6.22
3" Sheeting at $30 M	1.85
Pipe and channels	1.22
Tools, Boots, etc.	.42
	$ 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	76.50
		$192.11

Unit Cost

Pouring Cost 192.11/30	$ 6.40
Runways[1]	1.00
Water[2]	.05
Sand & Gravel loss[3]	.04
	$ 7.49

1116 yds. at $7.49 = $8,360

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

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

[3]Estimated 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%	.008	
	.186	
22,704 sq.ft. at .186 = $4,220		
Plus $320[8]	320	$4,540

Curved Forms[6]

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

Lower Forms[7]

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

Elevator Shafts & Stairways[8]

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

[1]In figuring panels the lumber is figured at 2 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 5¢ 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.

[2]Two cents includes cost of wire and tying.

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

[4]Panel erection cost.

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

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

[7]The 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% loss per use for repairs.

[8]Item at 5¢ additional per sq.ft. of outside wall forms due to the difficulty of installing in trenches.

REINFORCING STEEL

The quantity was figured by rule of thumb, 90 lbs. per yd. of concrete. This works out surprisingly accurately for ordinary substructure 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.

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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	475.00
	$2690.00

CONCRETE FINISH

The prices were taken arbitrarily, the curved concrete for overhead 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)	600.00
		$7750.00
		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

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.

9'-0" 10'-0" 9'-8" 9'-8" 9'-8" 8'-10"

① 561.03 558.03 ② 561.03 557.53 ③ 561.03 557.70 ④ 561.03 557.70 ⑤ 561.03 557.70 556.73 553.70 ⑥ 561.03 558.11 549.02 546.10

4:1 angle of repose

9'-4" 9'-8" 9'-4" 9'-0" 9'-8" 9'-11"

⑦ 557.56 554.40 ⑧ 557.56 554.23 ⑨ 557.56 554.40 ⑩ 556.99 553.99 557.56 554.56 ⑪ 557.56 546.60 547.90 546.07 ⑫ 542.02 538.60

9'-4" 9'-8" 9'-8" 9'-8" 9'-8" 9'-11"

⑬ 557.56 554.40 ⑭ 557.56 554.23 ⑮ 557.56 554.23 ⑯ 558.96 550.13 557.56 554.22 ⑰ 545.88 542.53 554.52 544.65 ⑱ 538.50 535.08

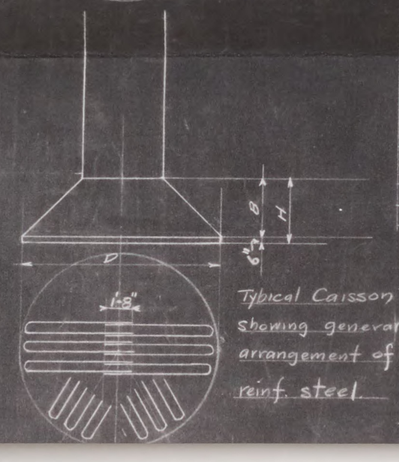
8'-9" 9'-11" 9'-4" 9'-8" 10'-0" 8'-10"

㉑ 557.56 554.73 ㉒ 557.56 554.14 ㉓ 557.56 554.40 ㉔ 553.96 550.63 557.56 554.22 ㉕ 547.91 543.71 554.52 544.65 ㉖ 538.50 535.68

Reinforcing Method of Bracing Exterior wall Trenches

Caisson Schedule

Col Nos	D	B	H	Total Bars	Lgth
19	8-9"	2'-4	2'-10	18-½" ϕ	4'-8
6, 24	8-10"	2'-5	2'-11	18-½" ϕ	4'-9
1, 10	9-0"	2'-6	3'-0	18-½" ϕ	4'-10
7,9,13,21	9-4	2'-8	3-2	18-½" ϕ	5-0
3,4,5,8	9-8	2-10	3-4	18-½" ϕ	5-2
11,14,15,16	9-8	2-10	3-4	18-½" ϕ	5-2
17,22	9-8	2'-10	3-4	18-½" ϕ	5-2
12,18,20	9-11	2-11	3-5	18-½" ϕ	5-3
2-23	10-0	3-0	3-6	18-½" ϕ	5-4



Typical Caisson showing general arrangement of reinf. steel.

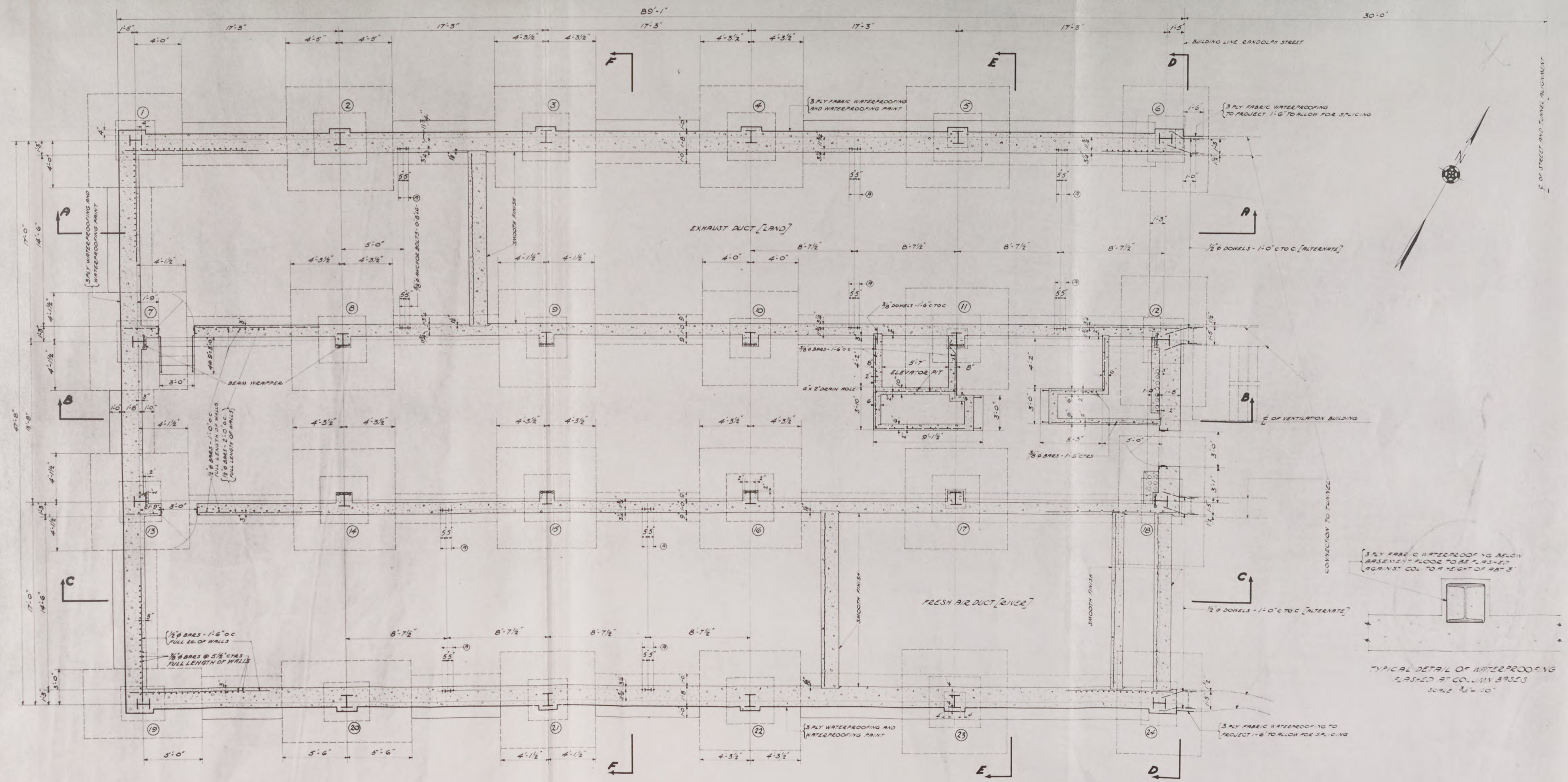
Note All Caisson shafts 4'-0 diam
Reinf for bell as scheduled divided into six bands of three bars (six legs) each and arranged as shown.
All waterproofing to be Ironite Method
Elev. shown are top of conc. & bot. of bell.

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

DETROIT VENTILATION BLDG
FOOTING AND WALL PLAN

THE SPENCER WHITE & PRENTIS CO.
ENGINEERS & CONTRACTORS

DATE	REVISIONS	FILE NO.
5/20/29	6/1/29 9/18/29	204-1



BASEMENT FLOOR PLAN

LIST OF REFERENCE DRAWINGS

1 LOCATION PLAN
2 FOOTING PLAN
4 FIRST FLOOR FRAMING PLAN
5 LONGITUDINAL SECTION A-A
6 LONGITUDINAL SECTION B-B
7 LONGITUDINAL SECTION C-C
8 CROSS SECTION D-D & MISC DETAILS
9 CROSS SECTIONS E-E & F-F
10 SECTION G-G
11 ELECTRICAL CONDUIT SYSTEM BASEMENT FLOOR
12 DUCT RUNS - CABLE GALLERY TO 1ST FLOOR - ELECTRICAL SYSTEM

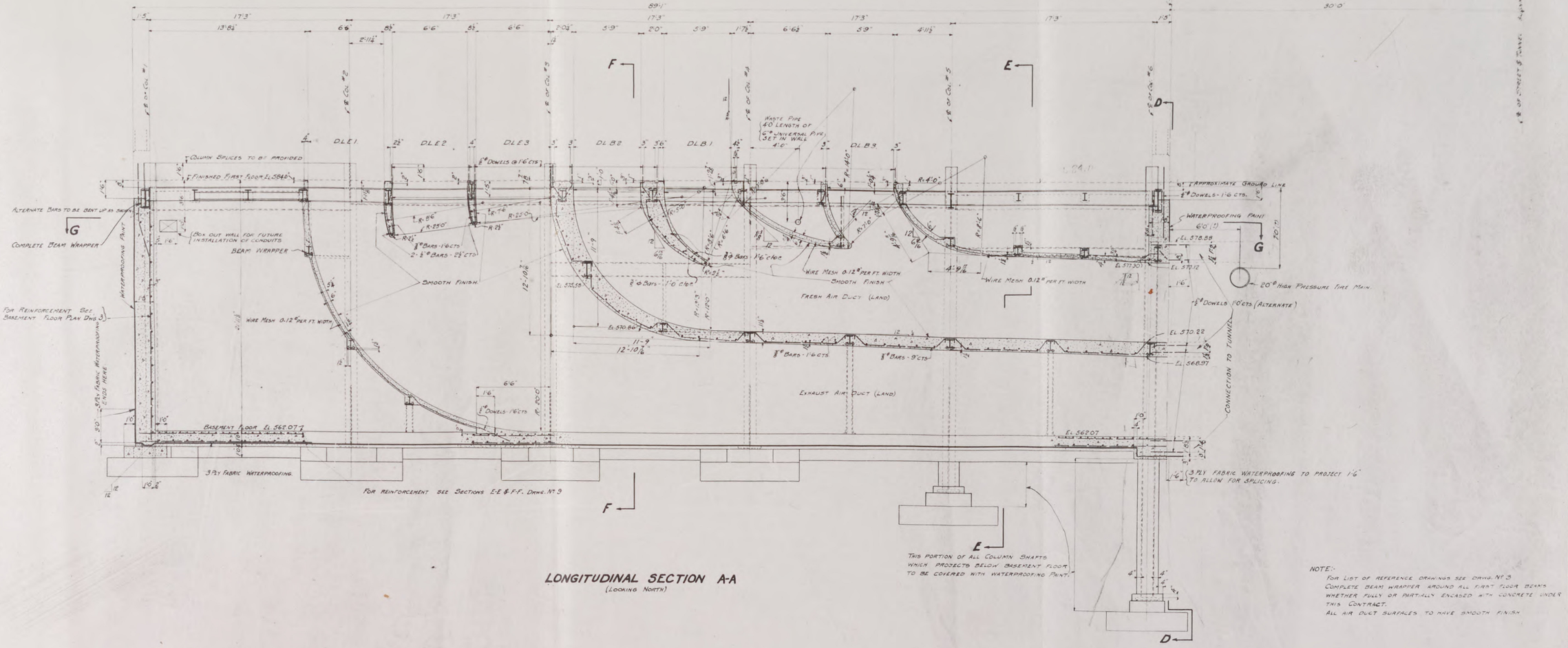
J. A. Thoresen
ENGINEER OF DESIGNS

DETROIT & CANADA TUNNEL COMPANY

PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS
ENGINEERS

DETROIT VENTILATION BUILDING
SUB STRUCTURE
BASEMENT FLOOR PLAN

MADE BY C.S.
CHECKED BY F.J.
APPROVED
SCALE
DATE
3



LONGITUDINAL SECTION A-A
(LOOKING NORTH)

NOTE:-
For List of reference drawings see Drwg. N° 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

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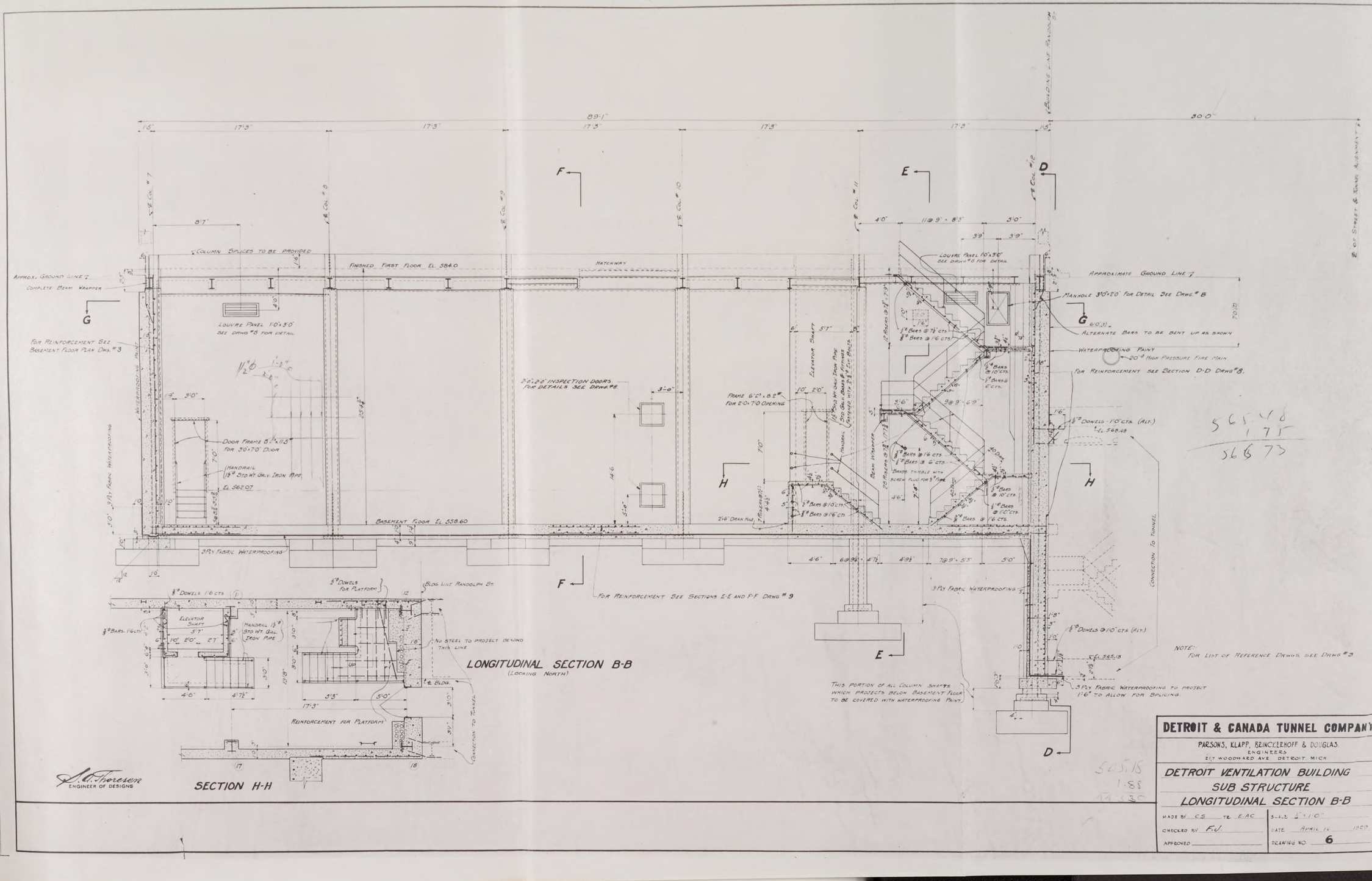
DETROIT VENTILATION BUILDING
SUB-STRUCTURE
LONGITUDINAL SECTION A-A

MADE BY C.S. TR. E.A.C.	SCALE ¼"=1'0"
CHECKED BY F.V.	DATE APRIL 16 1929
APPROVED	DRAWING NO. 5



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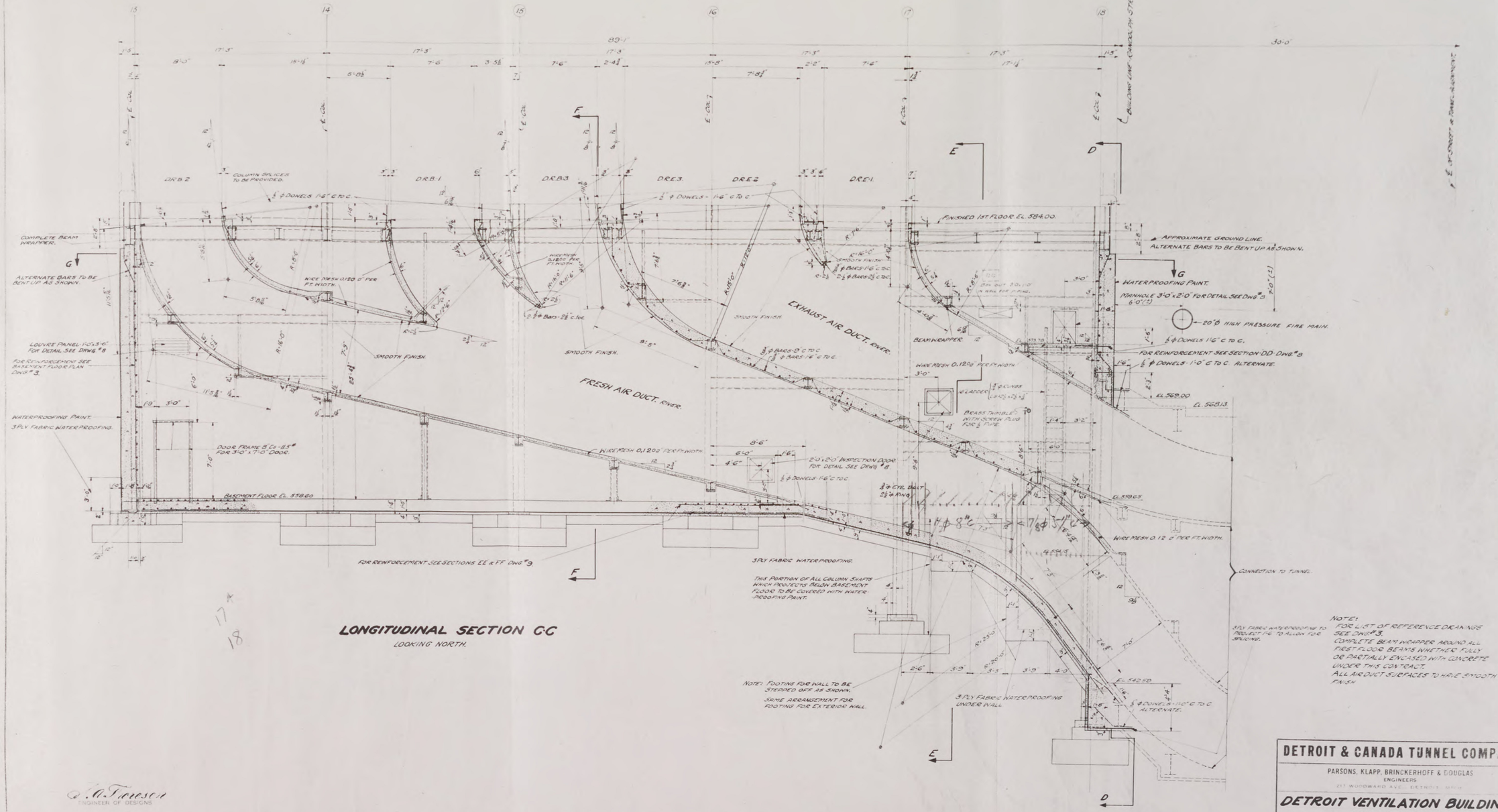
DETROIT VENTILATION BUILDING
SUB STRUCTURE
LONGITUDINAL SECTION B-B

MADE BY CS TR. EAC	SCALE ¼"=1'0"
CHECKED BY F.J.	DATE APRIL 14 1920
APPROVED	DRAWING NO. 6

565.16
1.75
5673

565.15
1.85
5673



LONGITUDINAL SECTION C-C

LOOKING NORTH.

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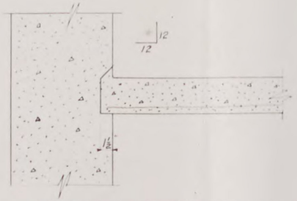
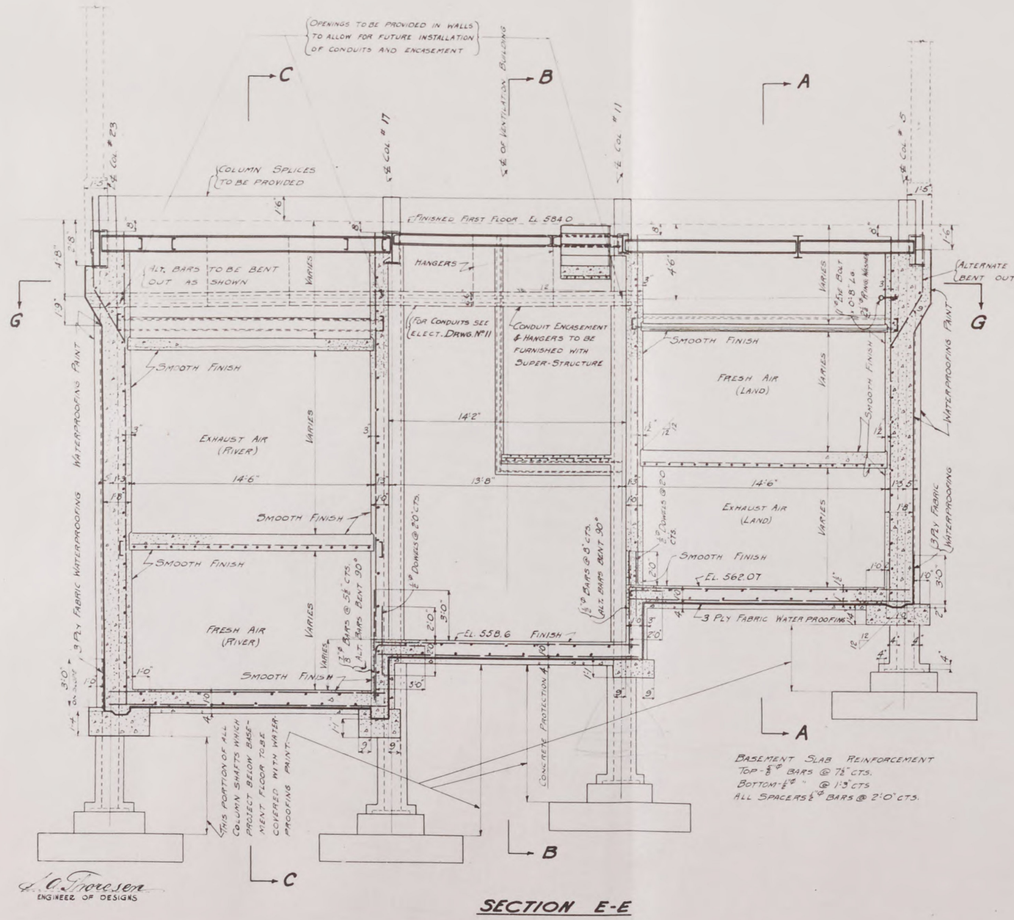
DETROIT VENTILATION BUILDING.
SUB-STRUCTURE.
LONGITUDINAL SECTION CC.

MADE BY C.S. TR. H.S.S	SCALE 1/4"-1'-0"
CHECKED BY F.J.	DATE APR.-16 1929
APPROVED	DRAWING NO. 7

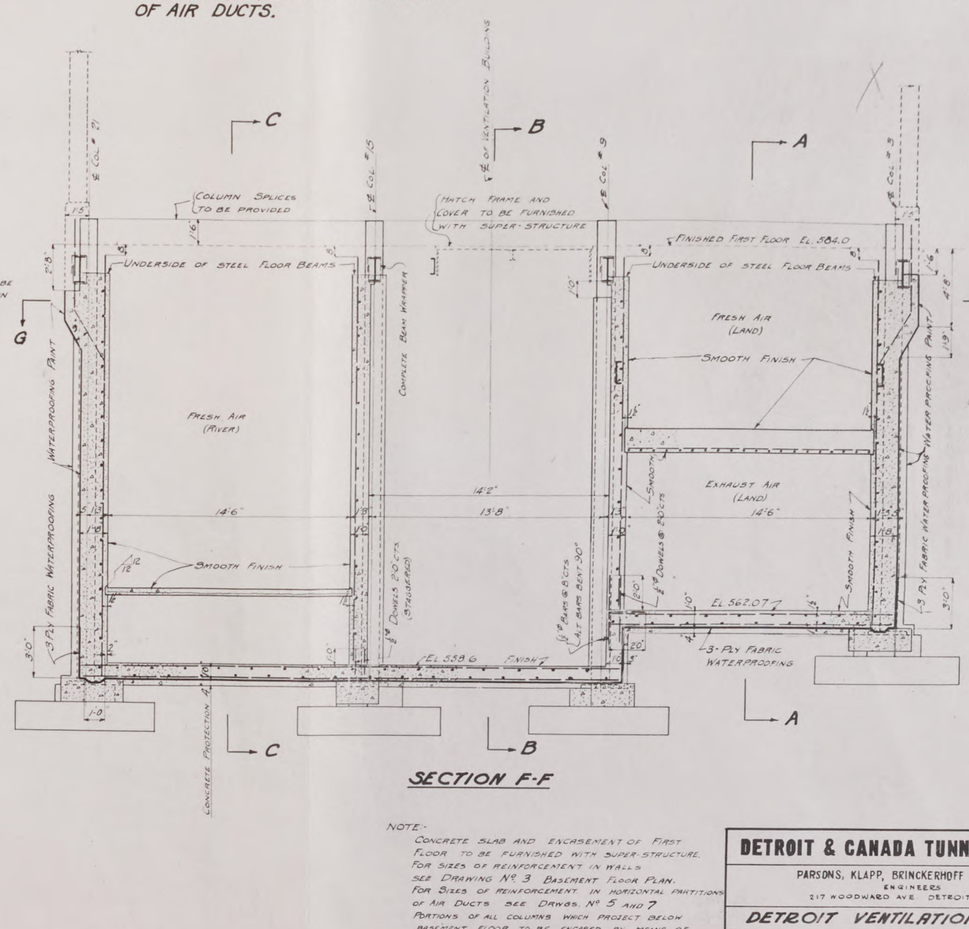


ENLARGED DETAIL OF WALL CHASE TO TAKE HORIZONTAL PARTITIONS OF AIR DUCTS.



BASEMENT SLAB REINFORCEMENT
TOP - ⅝" BARS @ 7½" CTS.
BOTTOM - ⅝" @ 1'3" CTS
ALL SPACERS ⅝" BARS @ 2'0" CTS.

SECTION E-E



SECTION F-F

NOTE:-
Concrete slab and encasement of first floor to be furnished with super-structure.
For sizes of reinforcement in walls see Drawing N° 3 Basement Floor Plan.
For sizes of reinforcement in horizontal partitions of air ducts see Drwgs. N° 5 and 7.
Portions of all columns which project below basement floor to be encased by means of beam wrapper.
For list of reference Drwgs. see Drwg. #3.

H. C. Thoresen
ENGINEER OF DESIGNS

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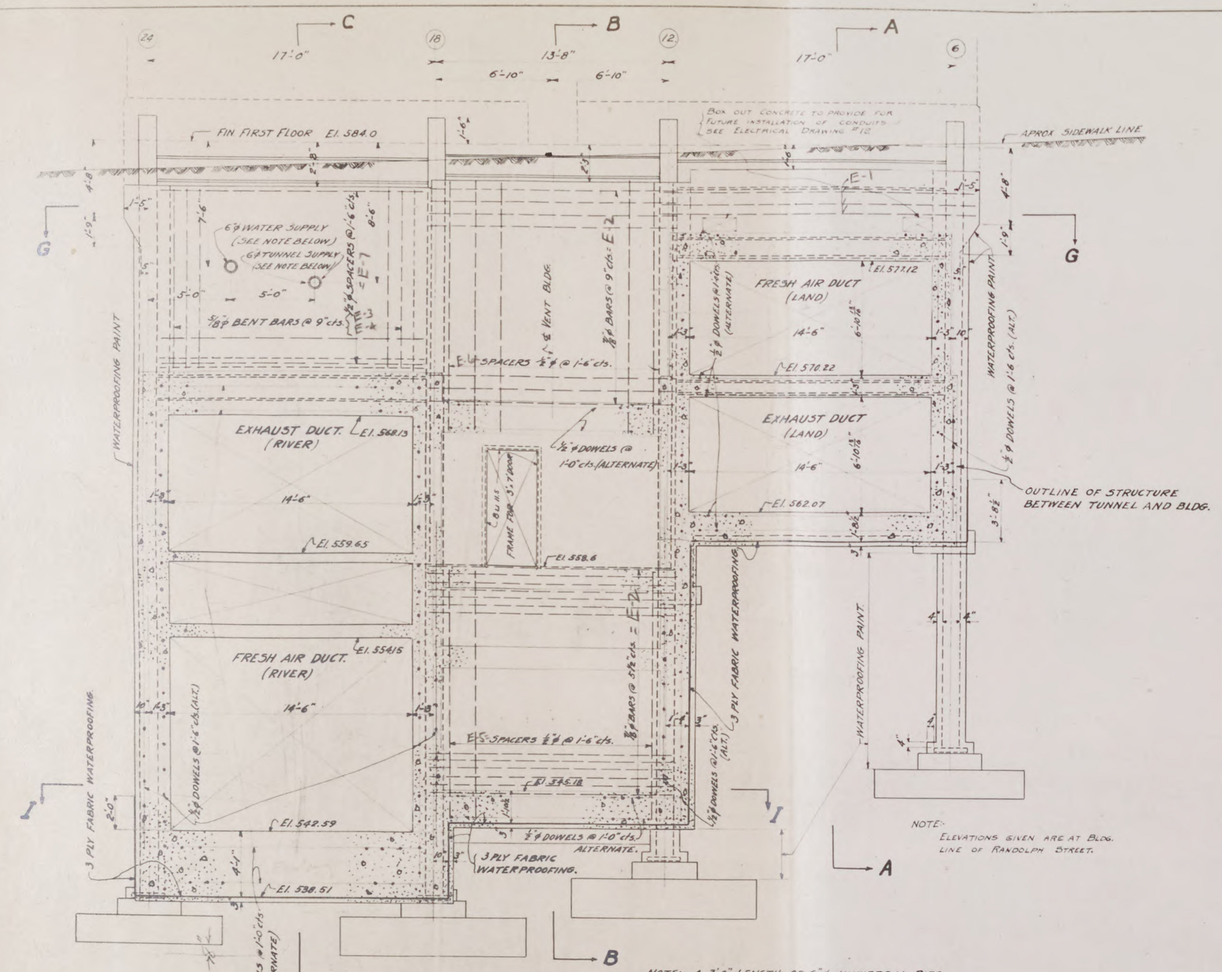
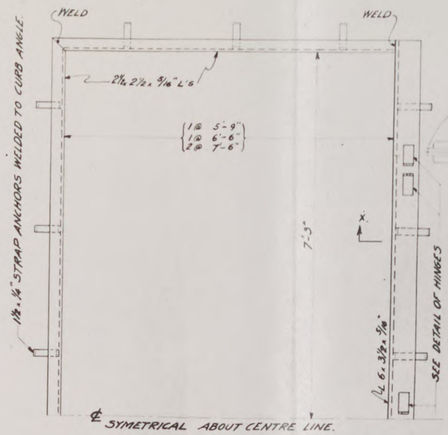
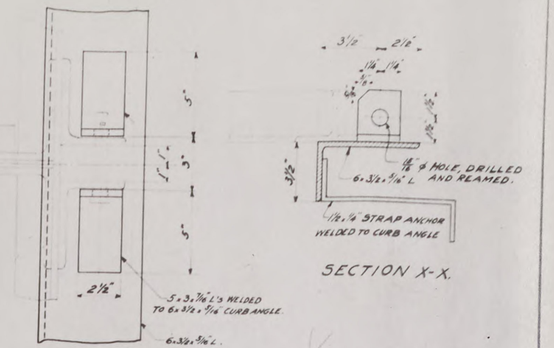
DETROIT VENTILATION BUILDING
SUB-STRUCTURE.
CROSS SECTIONS E-E AND F-F

MADE BY R.F.S. TR. E.A.C.
CHECKED BY F.J.
APPROVED
SCALE 1/4" = 1'-0"
DATE APRIL 16 1923
DRAWING NO. 9

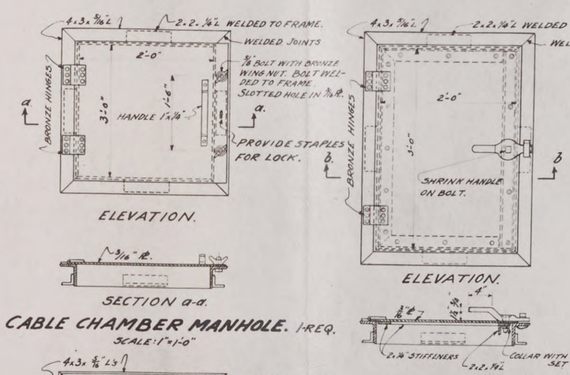


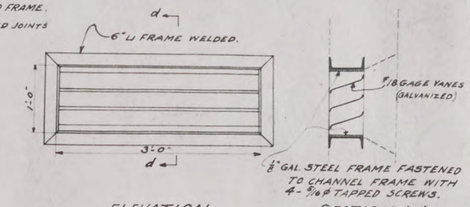


PLAN OF DAMPER SEAT.
SCALE: 3/4"=1'-0"



DETAIL OF HINGES.
SCALE 3"=1'-0"





LOUVRE PANEL.
SCALE: 1"=1'-0"

NOTE: FOR LIST OF REFERENCE DRWGS SEE DRWG #3

S. A. Stonesell
ENGINEER OF DESIGNS

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217 WOODWARD AVE. DETROIT, MICH.

DETROIT VENTILATION BLDG. SUB STRUCTURE. CROSS SECTION D-D & MISC. DETAILS.

MADE BY A.B. EERS TR. AB	SCALE 1/4" = 1'-0" Unless noted
CHECKED BY F.J.	DATE APRIL 16 1929
APPROVED	DRAWING NO. 8.