[VC 13]

# THE EARTH SLIDE ON ST. FRANCIS HILL

Early in January of this year, the attention of the Department was called to the very serious condition of the residence property on St. Francis Hill lying between Macleay Boulevard and the St. Vincents Hospital The entire hillside appeared to be in motion, causing considerable inconvenience and concern to property owners and threatening the hospital at the foot of the hill. Immediate action was necessary and after an examination of the area affected, steps were taken to arrest further progress of the slide. This work has just been completed; the details and methods followed and the conditions involved were as follows:

## HISTORICAL

St. Francis Hill was laid out and the roadways and other improvements constructed in the year 1911. The entire zone is of an argillaceous formation with intermittent layers of ~~strata of~~ hardpan and shale. The material excavated in constructing the roadways was mostly used in filling depressions in the surface and to form a nearly uniform surface contour. A number of springs was encountered while excavation work was in progress. A spring was also encountered on Lot 18 which later was filled for a depth of several feet in the development of a building site. I am also informed that a portion of Maywood Drive was excavated to a sub-grade of an elevation 7 feet below the present grade of the roadway. The streets were paved with a concrete pavement with sidewalk on both sides and sewer and water mains were installed. In December, 1912, a general settlement took place, accompanied by a slight lateral movement and several breaks appeared below Maywood Drive. The owners of the property then took steps to install a drainage system consisting of tunnels and shafts; this work being completed in February 1913 - the plan (Fig.7) clearly shows the general lay-out of this system. A slight movement continued, however. The sewer and water mains were uncovered and found to be considerably out of alignment, these trenches

subsequently filling with water, due to the inflow of ground and subterranean waters from the upper slopes. In December, 1913, a very noticeable movement occurred; many large cracks appearing in the concrete pavement on Maywood Drive and the north curb separating considerably from the pavement, accompanied by a very perceptible settlement. The entire hill side showed indications of movement and it was at this time the Department undertook to arrest the progress of the slide on account of the perilous location of the hospital and the damage and attendant loss of life that would occur in the event of a general slide resulting from the increasing movement.

SLIDE CONDITIONS

The area or zone embraced by the slide is indicated on the map (Fig 7). The concrete pavement on Maywood Drive for a length of 260 feet, was considerably cracked and showed signs of upheaval in various places; and at other points was broken entirely through; the slabs overlapping and rendering this portion of the roadway entirely unfit for traffic. The cement sidewalk slabs were raised from their foundation and moved over the curb. The retaining wall along the north property line of lot 17 was overturned and the steps leading to the residence on this property entirely destroyed. At the top of the slope (fig.7) a break was noticeable extending throughout the length of the zone in the form of an ellipse. Another break was traceable on the ground below Maywood Drive indicated on Fig. 7 as Break No. 2. Just above Maywood Drive on Lot 18 there existed a large depression (Section on line D Fig 6), which was apparently caused by settlement of filled ground. This acted as a sump and during the rainy season must have collected considerable surface water. The north curb of Maywood Drive had been forced away from the pavement and moved laterally nearly a foot in many places, the pavement remaining in place, due to its arch action causing the earth to slide under the pavement (Fig. 2). Careful measurements indicated a daily movement and needless to say, the existing conditions as a whole represented a very serious state of affairs, not only to the property owners within the limits of the zone, but also to the hospital officials; serious not only in the damage that had been wrought, the extent of which was apparent to even a casual

observer, but also in the fact that adjoining property owners could not feel assured that their property might not at some future time be similarly affected, and in the event of a general slide occurring, the danger to the inmates of the hospital was very apparent.

REMEDIAL WORK

After making a hurried examination of the exterior conditions, borings were made along the line of the old tunnel, disclosing the existance of a hard stratum at depths varying from 10 to 15 feet. It was determined to construct a drainage trench along the south property line of Maywood Drive for a distance of about 200 feet westerly from the east line of lot 17, thereby utilizing a portion of the old tunnel, this trench to drain east and west towards the existing shaft at A (fig. 7), the water then to be conveyed from the shaft through the tunnel. This tunnel was found to be in fair condition, heavily timbered and lagged.

Material was ordered and construction immediately begun. A careful survey was made and all points "tied-in" and stations established from which to observe the progress of the movement. These observations were made daily, the results of which are shown in table (Fg. 9). At the time construction was begun, the movement was averaging 1/4 of an inch per hour, causing the curb to work away from the pavement at the rate of 6 inches per day. The total movement up to the time the trench was constructed was nearly 5 feet. This caused considerable difficulty in excavating and holding the trench in line. Owing to this movement and treacherous character of the soil, heavy timbers were used in the trench, these consisting of 3-inch sheeting and 6" x 6" wales and shores. The trench was constructed in sections 6'6" long in two lifts, the first being 6' wide over all and 6' feet deep, the second 4' wide with an average depth of 6'. The trench was started about 2 feet south of the tunnel, the idea being that the lateral movement would carry the new work approximately over the roof of the tunnel. This movement was greater than anticipated, however, and the trench was carried about 2 feet north of the tunnel during construction (See Sections Fig. 8). Excavation

near Shaft "A" was carried to a depth of about 5 feet below the hard stratum of blue clay, which, in its wetted condition, formed the plane upon which the superimposed material was sliding. The trench was constructed so as to afford a grade of 1 inch per foot ascending easterly. When a length of about 35 feet was reached the bottom of the trench intersected the blue clay stratum due to a downward pitch of the latter; this necessitated excavating to a greater depth (Point "X" Fig.8). At this point, it was exceedingly difficult to hold the ground, owing to excessive over-burden and surcharge of the upper slopes and as the timbers were being strained to the utmost, we increased the number of cross-timbers and waling pieces and excavated to a depth of 7 feet below the stratum of blue clay and continued easterly on an ascending grade of 1 inch per foot. At a point 70 feet from Shaft "A", the clay stratum suddenly faulted and divided into two layers, one layer breaking downward and the other raising towards the surface. We continued about 6 feet easterly to the intersection of the bottom of the trench with the clay strata, raised and followed the upper strata to the east line of Lot 17. We followed the upper stratum for the reason that the movement was considerably less at this point and it did not seem advisable to attempt to excavate to the lower stratum on account of its very abrupt downward pitch. This would have considerably increased the cost of the work and in the event of its being necessary to resort to this latter, the work already done would not be lost, and furthermore, the movement now seemed to be under control. As the work progressed, two 6- inch sewer pipes were laid with open joints in the bottom of the trench, the pipes being well bedded in gravel, and the balance of the trench filled with crushed rock to within 2 feet of the surface; the timbers were not removed. Figs. 4 and 5 show the trench in its partially-filled condition. The up-hill side of the trench was first covered with a straw mat to resist the tendency of fine particles of clay and silt to percolate through the crushed rock and interfere with the drainage. At point "X", Fig. 8, the pipe in the lower trench was connected with two

similar pipes laid on the floor of the tunnel; these latter pipes were laid with cemented joints. These pipes, as well as the pipes in the upper trenches, were connected to a basin consisting of a 3' x 3' x 1½' brick box provided with a removable cover. From the box the water was conveyed through a single line of 6 inch pipe laid with cemented joints on the floor of the tunnel "Y" (Fig. 7) to a wooden flume carrying the water to the sewer in Marlborough Avenue. At the upper ends of the high level trenches two 6 inch pipes were carried vertically to the surface for the purpose of flushing out the drainage system, should this be necessary in the future. Fig. 8 shows a section and cross-sections of the system as constructed. The pavement has not been replaced at this date, as it was deemed advisable to wait until the effectiveness of the system was proved beyond a doubt. The movement, however, has been entirely checked and the writer does not anticipate further trouble in this immediate vicinity. Several surface drains were also constructed and connected to the sewers at different points. The total cost of this work was $1520.00

CONCLUSIONS AS TO CAUSE OF SLIDE

The writer is of the opinion that the slide was caused primarily by the excavation of Marlborough Avenue and Maywood Drive and the subsequent clearing of the vegetation and timber growth on the slopes and neglect in providing an effective drainage system at the time the improvements were made. The argument may be advanced that because the material did not immediately move at the time these improvements were made the slide was due to other causes. This, however, does not logically follow; the forces resisting the movement may have been strained almost to the breaking point and the mass finally set in motion from some other source. No doubt the infilteration of surface water added to that of subterranean springs constantly increasing in volume and added to the already lubricated state of clay sub-stratum, reduced the coefficient of friction and set the mass in motion. The entering of surface water would in this case, not be the fundamental cause, but rather a contributing factor.

Howard W. Hales

HWH R

Chief Bureau of Highways & Bridges

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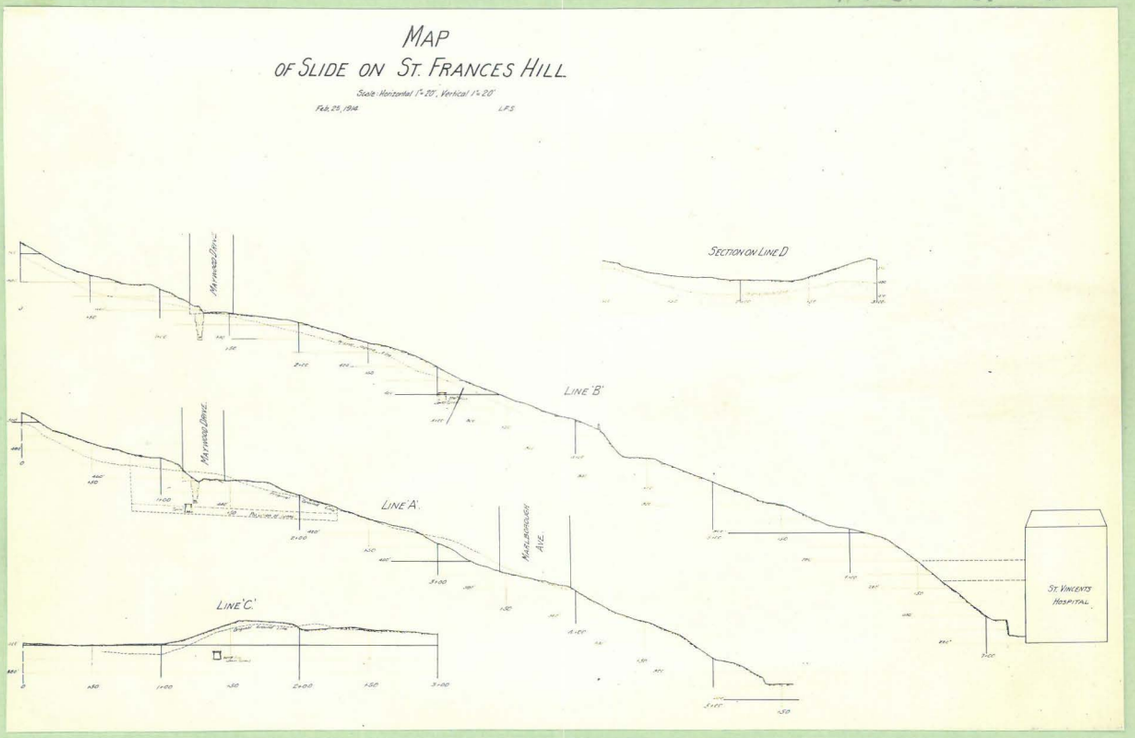


FIGURE 6

SECTIONS THRU AFFECTED AREA

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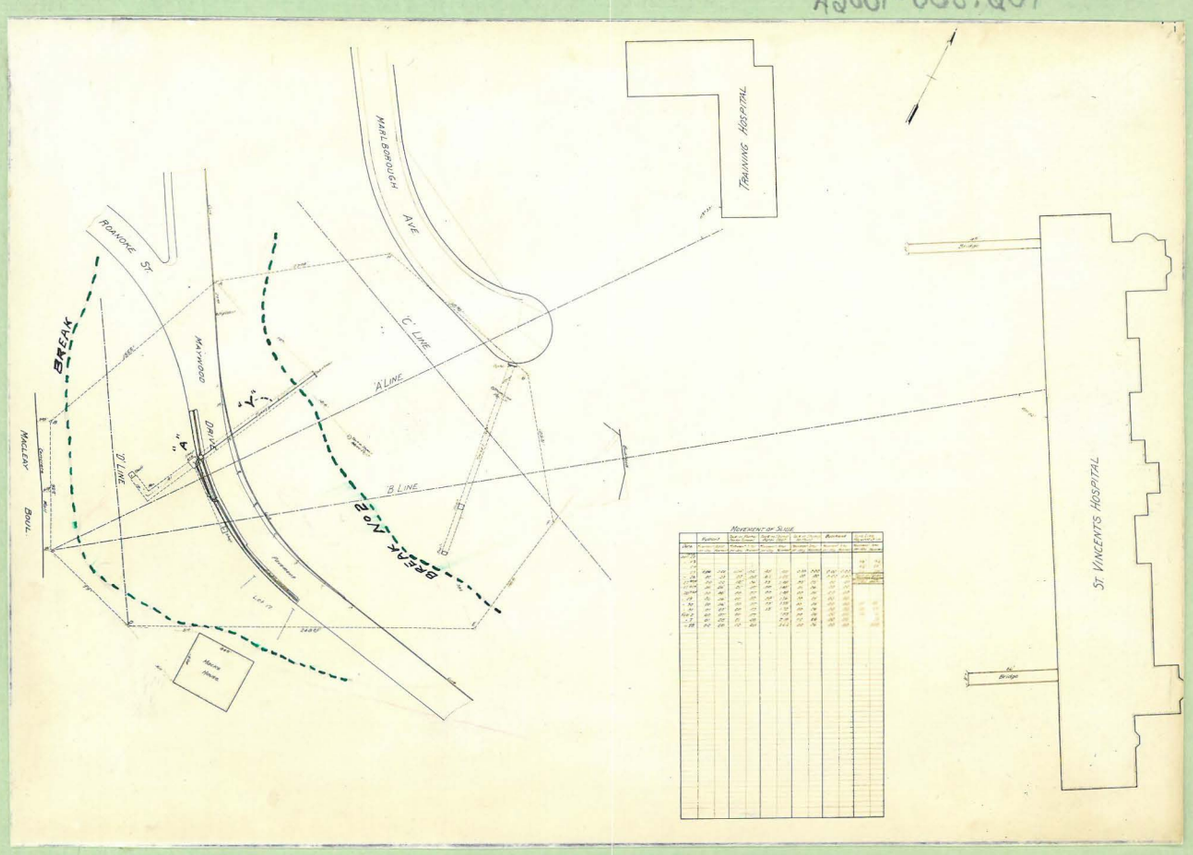
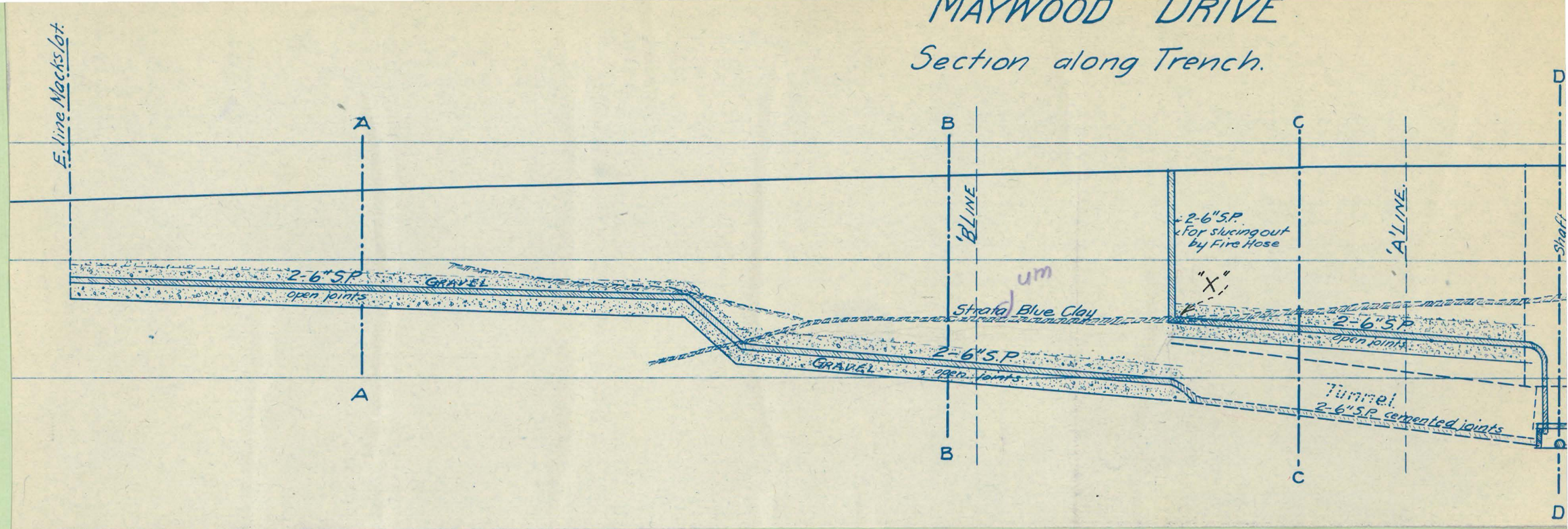
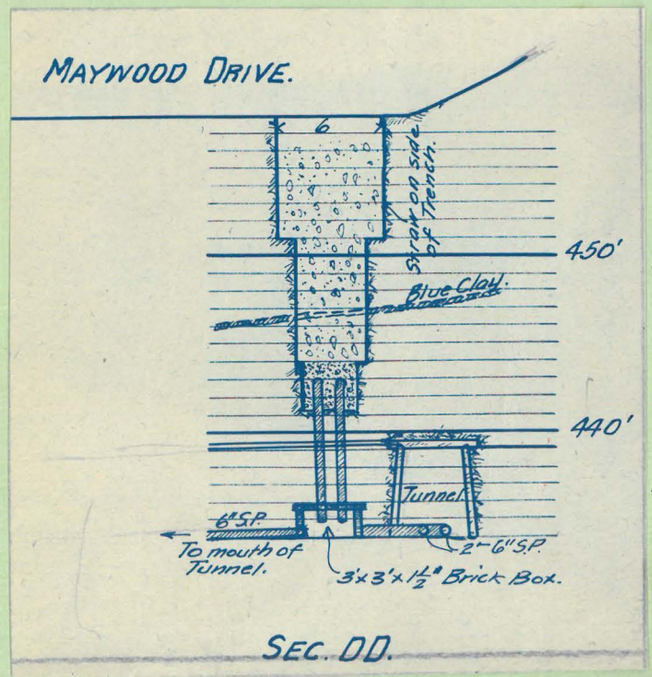
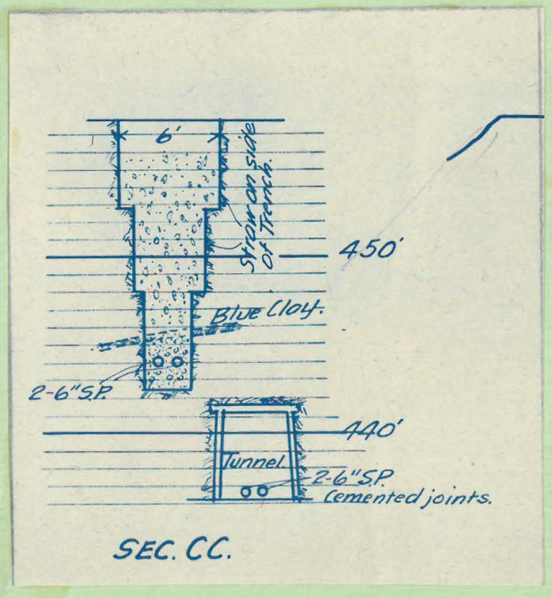


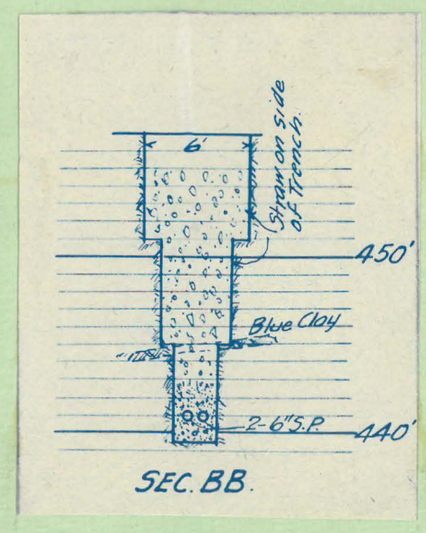

FIGURE 7

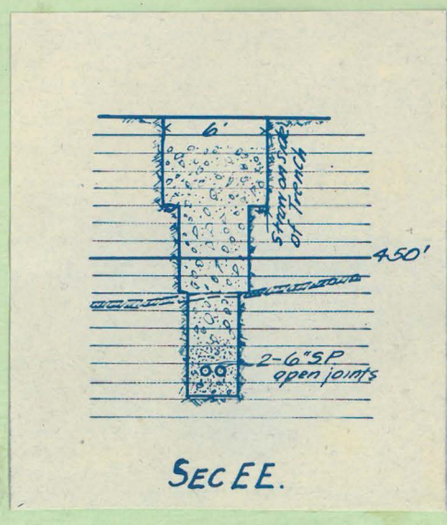
GENERAL PLAN SHOWING LAYOUT OF OLD TUNNELS AND SHAFTS AND POSITION OF NEW DRAINAGE TRENCH.



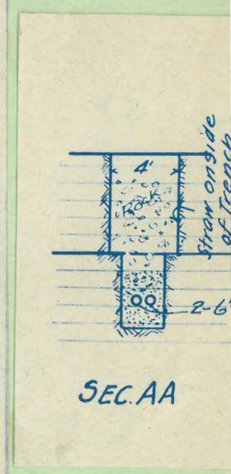
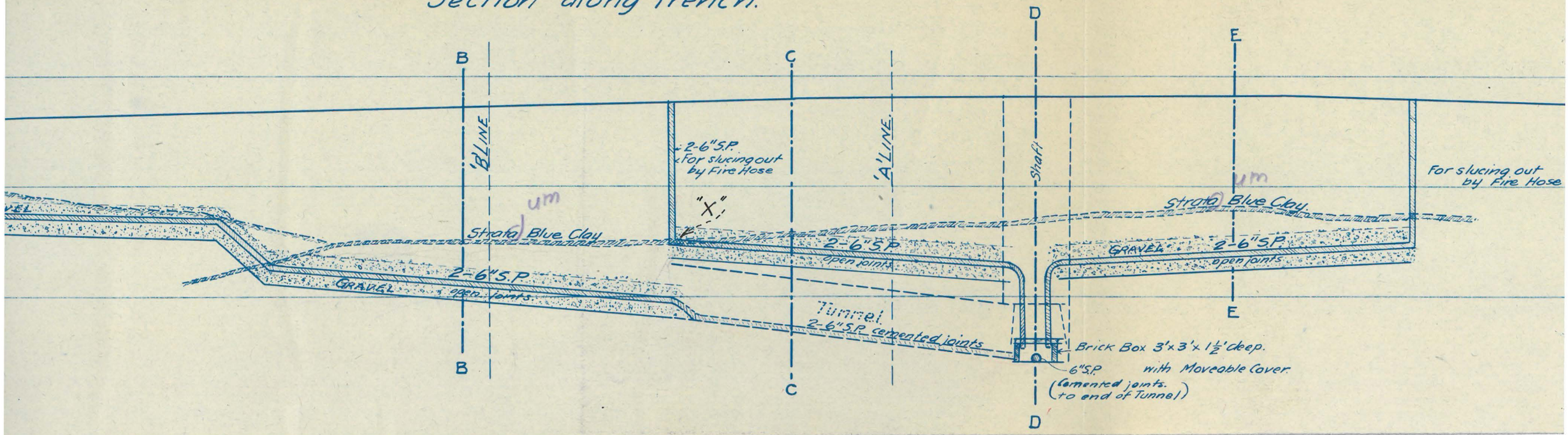



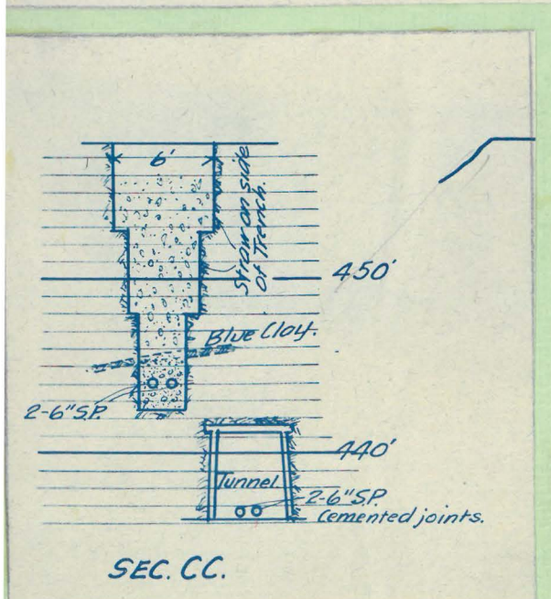

FIGURE 8

SECTION AND CROSS-SECTIONS OF TRENCH AS CONSTRUCTED.

# MAYWOOD DRIVE

## Section along Trench.

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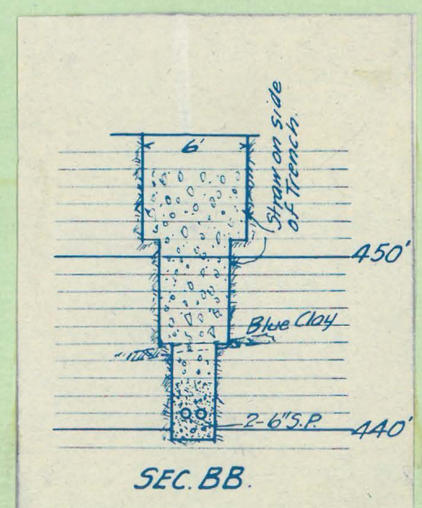


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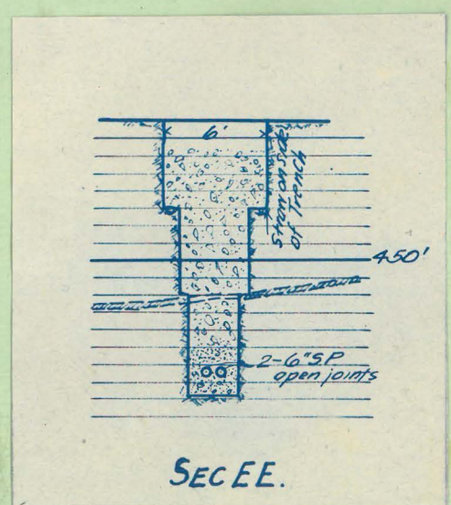
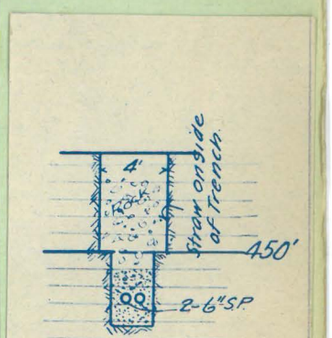



SEC EE.




SEC. AA

FIGURE 8

SECTION AND CROSS-SECTIONS OF TRENCH AS CONSTRUCTED.

# MOVEMENT OF SLIDE

| | Hydrant | | Tack in Portal North Tunnel | | Tack in Stump Water Dep't. | | Tack in Stump on Point | | Bulkhead | | Curb Line Maywood Drive | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Movement per day. | Total Movement | Movement per day. | Total Movement | Movement per day | Total Movement | Movement per day | Total Movement | Movement per day | Total Movement | Movement per day | Total Movement |
| 1914. Jan 22. | | | | | | | | | | | | |
| " 23 | | | | | | | | | | | $16\frac{1}{2}$" | $16\frac{1}{2}$" |
| " 24 | | | | | | | | | | | $6\frac{1}{2}$" | 23" |
| " 25 | 0.00 | 0.00 | 0.04' | .04' | .40' | .40' | 0.00 | 0.00 | 0.00 | 0.00 | $5\frac{1}{2}$" | $28\frac{1}{2}$" |
| " 26 | .00 | .00 | .00 | .04' | .65' | 1.05' | .00 | .00 | 0.00 | 0.00 | Tack in Pavement | Timber Drive |
| " 27 9AM | .00 | .00 | 02' | 06' | .43' | 1.48' | .05' | .05' | .00 | .00 | Movement per day | Total Movement |
| " 27 4PM | .06' | .06' | .01' | .07' | .00 | 1.48' | .01' | .06' | .00 | .00 | | |
| " 28 9AM | .00 | .06' | .00 | .07' | .00 | 1.48' | 00 | .06' | .00 | .00 | | |
| " 29 | .00 | .06' | .00 | .07' | .08' | 1.56' | 00 | .06' | .00 | .00 | | |
| " 30 | .00 | .06' | .00 | .07' | .03' | 1.59' | 00 | .06' | .00 | .00 | .02 | .02 |
| " 31 | .01 | .07' | .00 | .07' | .13' | 1.72' | 00 | .06' | .00 | .00 | .27 | .29 |
| Feb 2 | .00 | .07' | .00 | .07' | | 1.83' | 00 | .06' | .00 | .00 | .34 | .63 |
| " 7 | .01 | .08' | .01 | .08' | | 2.18' | 00 | .06' | .00 | .00 | | 1.10 |
| " 28 | 00 | 08 | 00 | .08 | | 3.64 | .00 | .06 | .00 | .00 | .90 | 2.20 |
| Mar. 30 | .00 | .08 | .00 | .08 | | 5.25 | .00 | .07 | .00 | .00 | | 2.35 |
| Apr. 17 | .00 | .08 | .00 | .08 | | 5.72 | .00 | .07 | .00 | .00 | | 2.44 |
| June 2 | .00 | .08 | .00 | .08 | | 5.85 | .00 | .07 | .00 | .00 | | 2.47 |

FIGURE 9