A STUDY OF STADIA

AND A COMPARATIVE STUDY

OF TWO POSSIBLE STADIA SITES IN PASADENA

An engineering problem in connection

with the Senior Civil Engineering course at California Institute

of Technology

year 1919-1920

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LIST OF MAPS CHARTS ETC.

ORIGIN OF THE STADIUM.

In the days of ancient Greece the stadium was a measure of distance, one stadium being equal to 600 Greek feet, or 606 feet 9 inches in English measure. Since the stadium was the distance for most foot races, the term was applied to the place where the races were held. Originally, there was some natural hollow in which the events took place with the spectators seated on the surrounding slopes. The slopes were later graded so as to form a more regular enclosure and a better view for the spectators. The next step was to provide the slopes with seats of wood or stone. The largest and most famous stadia were at Athens and Olympia. Such places as Delphi and Messeni which were not favored by nature soon built the seats on a masonry sub-structure.

ANCIENT STADIUM AT ATHENS.

This structure was built by Orator Lycurgus about 350 B. C. and later about 200 A. D. seats of marble were added by Herodes Atticus, a wealthy Roman.

It went out of use and was nearly buried by the passing of time. King George excavated it in 1809. It has in late years been completely restored and through the Olympic games regained much of its former importance. Like nearly all Greek stadia it was horseshoe in shape, 669 feet long and 109 feet wide. It seated 50,000 people.

LATER DEVELOPMENTS.

From these stadia the Romans developed the more elaborate circus or amphitheatre. These were built on level ground, the seats being supported on elaborate arches and pillars. The space beneath was used for entrances, dressing rooms, and the like. They were used for horse and chariot races, and were circular or eliptical in shape.

Examples of these are the Circus Maximus at Rome which was 705 feet wide and 2200 feet long and seated 380,000 people and the Maxentius, two miles from Rome, which was 245 feet wide, 1620 feet long and seated some 150,000 people.

MODERN STADIA.

The revival of athletics in our colleges and universities has made it necessary to provide seating facilities for large crowds. The structure must be fire proof and free from danger of collapse. These requirements are well met by the use of reinforced concrete.

The first of such structures to be built in the United States was the amphitheatre at Berkeley, California constructed in 1903. It is a reproduction of the old Greek theatre of Dionysus. In the same year a stadium was built in Soldiers Field at Harvard. It resembled more closely the old stadia.

In 1906 Syracuse University built a stadium of reinforced concrete surface on cut and fill embankment for track meets and football games. In plan it forms an oval 670 feet long and 475 feet wide, with semicircular ends joined by a straight part 198 feet long. It has a normal seating capacity of 20,000. There is provision made for a football field 300 by 500 feet and a quarter mile running track 20 feet wide. In 1904 the Harvard University built its steel and reinforced concrete stadium to accommodate about 23,000 spectators. The Yale Bowl, completed in 1914, is the most collosal structure of its kind in the United States.

It is almost entirely an earth work and mass concrete stadium, the seat slabs being placed directly upon the earth embankment without supporting arches or beams. It is, in plan, a four center oval with outside dimensions of 750 feet by 950 feet. It has a seating capacity of 61,000 people. It encloses a football field 300 feet by 500 feet. It will be noted that no running track is provided.

The Princeton athletic stadium was built the same year (1914). It forms a marked contrast to the Yale Bowl in that the entire seating slope is supported on arches and pillars of reinforced concrete. It is horseshoe in plan being composed of two parallel straight portions 454 feet long, 240 feet apart joined at one end by an elliptical part. It encloses a football field, a quarter mile running oval, and a 220 yard straightaway twenty feet wide. It will seat 20,000 people.

COMPARISON OF TYPES.

There are two principle types of stadium which might be considered for Pasadena: the bowl and open-end types. Each has its advantages and disadvantages, depending on what sports it is to be used for.

The bowl type is the one best suited for football, since it gives more seats, and the curved sides give everyone a clear view of all parts of the field. However, it has the disadvantage that it is impossible to include a two hundred and twenty yard straightaway due to the curved sides and the excessive length that would be required.

The open type can very well include both a football field and a track. It is not quite as suitable for football as the bowl, but is satisfactory enough, and has the advantage of adaptability to both sports. The straightaway can start outside at the open end and finish in front of the stands. The blank retaining wall rising some twenty five feet at one end, as would be necessary at either of the proposed sites, is, however, a drawback from the aesthetic point of view. A crowded section of grandstand may not have any particular beauty, but it has a certain quality of life and interest, whereas a retaining wall possesses neither of these qualities to offset its lack of beauty.

The bowl type then seems better if it is desired to build the stadium purely for football and depend on the annual game to support it..If the track events are also desired, then the open type would be more suitable.

TYPES OF CONSTRUCTION.

Either of two forms of construction may be satisfactorily used: the earth fill form, as used in the Yale Bowl or the reinforced concrete beam form, as used in the Princeton Stadium. In each case about half of the seats are usually in cut. With the earth fill type the earth taken from this cut is used to support the rest of the seats, while in the concrete beam type the seats are built on a sub-structure of reinforced concrete beam construction.

This latter form has marked advantages from an architectural standpoint. The arcade of concourse around the outside, with columns and arches, has many possibilities for beauty and may also serve a very useful purpose as shelter in rainy weather.

With the earth fill type there must be either a high retaining wall or a fairly gentle slope around the outside. If a slope is used it must be covered to protect the dirt from washing away. Neither of these could be made very beautiful except at a prohibitive cost. The earth fill type is, however, much cheaper than the other form.

COMPARISON OF LOCATIONS.

Several factors enter into the choice of a location for a stadium. The question of accessibility is of prime importance and there must be room to handle the crowds when they arrive. Furthermore there must be plenty of parking room. Then, too, the way in which the structure fits into the surroundings must be considered. It would be so large that it would need plenty of room to appear at its best and would tend to dwarf any buildings which happened to be near it. The effect on adjoining property is important and must also be taken into account.

TOURNAMENT PARK.

AUTO TRAFFIC.

Tournament Park is an ideal location for automobile traffic. Autos may come from Los Angeles by either of three routes: up Fair Oaks and out California Street, up Huntington Drive and through Oak Knoll, or through Highland Park and out Colorado Street via the Colorado Street Bridge and Annandale. Only the latter route would pass through the business center of Pasadena, and this could be avoided by dropping to California Street on Orange Grove Avenue. Autos from Long Beach, Whittier, San Gabriel, etc., would come up San Gabriel Boulevard, thence on San Pasqual Street or California Street to the Park. The Foothill Boulevard traffic would come in Colorado Street, thence reach the Park by way of Huntington Drive and California Street or Wilson Avenue.

ELECTRIC CAR TRAFFIC.

Oak Knoll cars run on Lake Avenue, three blocks distant and may be turned onto California Street to the Park. The Short Line cars are some miles away and are useless unless transfer is made to local cars at the business center of Pasadena. The present California Street line would be inadequate for this combined Los Angeles and local traffic.

PARKING FACILITIES.

As seen by looking atsheet 6, there wouldbe no parking space available in the park providing such a stadium were built. The grounds of California Institute of Technology are rapidly being built up and improved and will soon no longer be available for parking. The vacant land to the south and west of the park is being rapidly improved and is too valuable to be used for parking. There is an area of some 30 acres to the west of the park which might be available for some time as parking space but it is not adequate and furthermore, there is no assurance of its permanent vacancy. The streets, of course, provide some space, but these should be kept clear to avoid congestion.

The area now available for parking is noted on Sheet 6.

SPACE FOR HANDLING CROWDS.

The stadium itself fits into the park so closely that there would be no room for crowds to scatter before reaching the street. It will be noted that the park has, at present, direct access to two streets, Wilson Avenue and California Street. There is a possibility that an entrance could be arranged from Arden Road on the south side as shown on sheet 6. This would be in the form of a steep ramp or a flight of stairs because of the rapid fall in grade in that direction as seen on sheet

EFFECT ON SURROUNDING PROPERTY.

The park is bordered on the South and east by the famous Oak Knoll residence district. Such a collosal structure, bringing crowds of people would meet with almost prohibitive protest from the residents of this district.

The park is bordered on the north and west by the California Institute of Technology and the ~~Throop~~ Polytechnic Elementary School. These institutions plan to beautify their land with buildings and garden effects and would suffer by the building of a stadium on the adjoining land. The park now contains tennis courts, a track, and a football field, all of which would be destroyed were such a stadium built in the park. These two institutions have done a great deal toward making these facilities possible and rely upon them for their athletics.

CUT AND FILL.

For a comparison of the cut and fill necessary at the two sites, we used the bowl type of stadium and assumed that the ratios of the amounts necessary at the two sites would be approximately the same for the horseshoe type. The volumes of cut and fill necessary for the ideal section are shown in the following table:

BALANCE OF CUT AND FILL.

Gross volume of superstructure		272,300 Cu. Yds.
Volume of voids		
25 tunnels - 7 x 8 x 180	28,000	
25 ticket offices - 9 x 9 x 8	1,800	
4 rest rooms - 18 x 10 x 8	640	
1 tool room - 18 x 10 x 8	160	
Lateral walls etc.	3,000	
Total voids	33,600	33,600
Net fill		238,700
Cut		238,100
Excess of cut over fill		600 cu.yd.

The excess of cut over fill is permissible to allow for the fact that earth expands slightly when excavated and never regains its original volume.

Since the ideal section, as shown, has practically equal cut and fill, its ground line should be located at such an elevation that the cut and fill necessary to make the gound surface level at that elevation would balance. To determine what this elevation should be, a series of north and south profiles were taken from the contour map, one every fifty feet over the ground covered by the stadium. We found that ideal ground line should be placed at elevation 735.5 The computations are shown on the next page.

Readings were taken from the profiles with a planimeter. The planimeter constant was four and the vertical scale of the profiles was exaggerated three times, hence the constant of 4/3.

Cut and fill

Ideal ground line at elevation 735.5

sect.	read. of plan. cut	fill	R cut - fill	True net values = 1600/3 R fill	cut
1	0.21	0.06	0.15		80
2	0.42	0.41	0.01		5
3	0.62	0.53	0.09		48
4	0.73	0.69	0.04		22
5	0.65	0.23	0.42		217
6	0.78	0.64	0.14		74
7	0.71	0.69	0.02		11
8	0.68	0.84	-0.16	85	
9	0.70	0.87	-0.17	91	
10	0.62	0.31	0.31		166
11	0.41	0.78	-0.37	197	
12	0.26	0.27	-0.01	5	
13	0.13	0.31	-0.18	96	

The last column in the table gives the areas of the cross sections at the various profiles. The volumes of cut and fill were computed from these by the prismoidal formula, taking the end areas as zero. These computations follow.

$$A = \frac{(0 + 320 + 5) \times 100}{6} = 5,400$$

$$B = \frac{(5 + 192 + 22) \times 100}{6} = 3,600$$

$$C = \frac{(22 + 868 + 74) \times 100}{6} = 16,070$$

$$D = \frac{(74 + 44 - 85) \times 100}{6} = 600$$

$$E = \frac{(-85 - 364 + 166) \times 100}{6} = -4,700$$

$$F = \frac{(+166 - 788 - 5) \times 100}{6} = -10,450$$

$$\underline{G} = \frac{(-5 - 384 + 0) \times 100}{6} = -6,480$$

Cut	Fill
5,400	4,700
3,600	10,450
16,070	6,480
600	21,630
25,670	

Excess of cut over fill = 4,040 cu.ft. = 149 cu.yd.

This is as close as the accuracy of our data warrants.

BROOKSIDE PARK SITE.

Accessibility.

Autos.

It will be noticed by referring to sheet 8 that there are many routes of access, either actual or proposed to this site. Autos coming from the south, by way of Orange Grove Avenue and from the west by way of the Colorado Street Bridge, would find it convenient to go north on Orange Grove to Linda Vista Street, thence through the present Brookside Park to the stadium site. Traffic from the west by way of Linda Vista Boulevard could, of course, use this entrance. Autos from Pasadena and the west could make use of the present Lester Avenue entrance to the park. Autos from the north, Lincoln Avenue, and the Foothill Boulevard would turn off at Seco Street which reaches the arroyo floor by an easy grade. The city now has a hundred foot right of way here and if the use warrants its, will improve it with paving.

If the Arroyo Seco Road from Los Angeles to Pasadena is built, it can be extended to the stadium site. It will be noticed by referring to sheet that there are small canyons or draws entering the main wash at points east and west of the site.

These canyons would provide excellent grades for roadways. The one from the west would connect with the Linda Vista Boulevard, giving a direct route to the country to the north and west. The one from the east could connect with Lincoln Avenue and provide a direct route to the north and east.

ELECTRIC CARS.

The Orange Grove Avenue line comes within some two blocks of the present Brookside Park, and to many people the walk of half a mile through the park would not be a hardship. For the others, the Lincoln Avenue line would be a more convenient route. There is a possibility that if the traffic would warrant it, a spur track might be run down Seco Street to the site. The use of the Orange Grove Avenue line for Los Angeles traffic would necessitate a transfer in Pasadena. The Los Angeles car could, however, be switched at the barns on Fair Oaks Avenue and run direct to the site, over the Lincoln Avenue line and the proposed extension.

PARKING SPACE.

It will be seen by referring to sheets 10 that there is an ~~vast~~ abundance of space, adjoining the stadium site, that might be used for parking. There are, however, several details which must be taken into consideration. The natural soil in the Arroyo is of a very rocky and sandy nature and would have to be resurfaced with dirt or macadam before it would be suitable for auto parking. The whole wash for years has been used for a dumping ground. This has left the ground covered with glass, nails, and other things which are death to tires. The best remedy for this condition seems to be to build a retaining wall along the lower and western border of the stadium site and scrape all of the surface dirt into the hollow behind the wall. This could then be covered with a few feet of earth and be transformed into a garden spot. It might be possible to recover enough scrap iron to make it worth while to sort it out.

SPACE FOR HANDLING CROWDS.

It seems useless to point out the ease with which the crowds could be accommodated in the park. Crowds of over 4000 have been entertained in that part of the park which is now improved and the portion which is not improved is at least five times this size. The park now holds several thousand people in picnic grounds and provides rest rooms and amusements for several hundred besides. The park is a natural mecca for picnics, athletics, and outdoor meetings of all kinds. There are at present tennis and croquet courts, a sod baseball diamond and a swimming pool, not to mention the large playground for children. All of these factors tend to make the site ideal for such an event as the annual football game on New Years.

EFFECT ON SURROUNDING PROPERTY.

As has been previously pointed out, the proposed site in Brookside Park is anything but attractive. It is even said that at times there is a strong odor arising from the piles of rubbish which have gathered there. The rubbish also affords a perfect starting place for fires which could spread to the fine homes which overlook the canyon.

There are no homes within such distance as to be harmed by the building of such a stadium at this site.

CUT AND FILL.

Ideal ground line at 806.0

sect.	plan.read.(sq.in.) cut	fill	R cut-fill	True values (1600/3 R) cut	fill
1	0.0	2.42	-2.42		1290
2	0.0	3.07	-3.07		1640
3	0.0	2.80	-2.80		1490
4	0.03	1.75	-1.72		917
5	0.22	1.30	-1.08		576
6	0.52	0.73	-0.21		112
7	0.57	0.78	-0.21		112
8	0.68	0.75	-0.07		37
9	1.25	0.36	-0.89	474	
10	1.94	0.22	-1.72	918	
11	2.33	0.03	-2.29	1220	
12	2.60	0.00	-2.60	1380	
13	2.71	0.00	-2.71	1445	

$$A = \frac{(0 - 5160 - 1640)}{6} = -113{,}000$$

$$B = \frac{(-1640 - 5960 - 917)}{6} = -142{,}000$$

$$C = \frac{(-917 - 2304 - 112)}{6} = -55{,}000$$

$$D = \frac{(-112 - 448 - 37)}{6} = -9{,}940$$

$$E = \frac{(-37 - 1896 - 918)}{6} = -46{,}200$$

$$F = (-918 - 4880 - 1380) = -119{,}000$$

$$G = \frac{(- 1380 - 5780 - 0)}{6} = - 119000$$

Cut	FIll
46,200 cu.ft.	113,000 cu.ft.
119,000	142,000
119,000	55,500
	9,940
284,500	320,440

Excess of cut over fill = 35,940 cu.ft. = 1,360 cu.yd.

This is close enough as there will be some expansion of the earth when it is excavated.

There must be moved, then, from this site about 302,000cu.ft. or 11,200 cu.yd.

DATA ON STADIA

STADIUM	YEAR BUILT	TYPE	SHAPE	SEATING CAPACITY	EXCAVATION CU. YDS.	CONCRETE CU. YDS.	LENGTH	WIDTH	COST PER SEAT
Athens	350B.C.	Cut & Fill	U	50,000			760'	200'	
Circus Maximus	100 B.C.	Masonry	Oval	380,000			2,200'	705'	
Maxentius	100A.D.	"	U				1,620'	245'	
Syracuse	1906	Cut & Fill	Oval	20,000	250,000	20,000	670'	475'	$25
Yale Bowl	1914	" "	Oval	61,000	175,000	127,000	930'	750'	7.35
College Of The City				10,000					36.00
Boston		Steel	Right Angle	24,000					
Harvard				23,000			652'	520'	
Princeton	1914	Reinf. Con.	U	41,000	40,000				8.50
Michigan	1914	" "	U						41.60