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The Design of the Flavian Amphitheatre

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The Flavian Amphitheatre



The Design of the Flavian Amphitheatre

*Barbara pyramidum sileat miracula memphis;
Assiduus jactet nel babylona labor...
Omnis Caesareo cedit labor amphitheatro
Unum praecunctis fama loquatur opus.*

--Martius. De Spect. 19

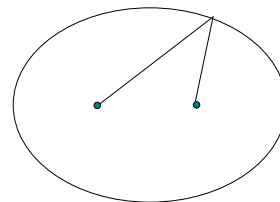
Introduction.

Among the hundreds of readily-found references to the building known variously as the Coliseum, the Colosseum or the Amphitheatre of the Flavians, there is a consistently appearing remark that the plan of the building is *elliptical*. Since many of these references provide a nice illustration, we immediately see before us that ellipse.

When the next question comes to mind, if indeed we allow ourselves to entertain such a question, we have a serious objection: how was this design put into effect. Nearly all popular sources on ellipses go into the string-and-two-nails construction [1], as not only a way to draw the conic section but in most cases the actual *definition* of the curve. We are left to imagine a squad of harried Roman engineers with 600 feet of handmade rope tied to two focal posts 300 feet apart, running smoothly over some sort of scribe, attempting on seven acres of uneven ground to execute an 1800-foot curve which even the simple illustrations show as a breathtakingly pure ellipse. We must ask whether the resulting shape was worth the effort!

But another objection comes immediately to mind. The construction of such a practical building is all about the seating, for which the engineer must set out dozens of rows with fixed width. If the outline is elliptical each parallel row of seats must be as well. But an easy calculation shows that sets of parallel ellipses demand constantly changing foci, so that the posts used for one ellipse must be moved to produce each parallel. What one might mean by the distance between two elliptical curves involves the very notion of “parallel ellipses”.

This really does seem to be an extraordinarily awkward means merely to produce a pleasant shape. It is our intention here to provide an answer to these objections and thus, first, to show that the Colosseum is not elliptical, and second, to produce an entirely workable solution to the true construction design.



The Building.

Julius Caesar is thought to have built at Rome some sort of temporary athletic stadium in 46 BC [2], although no details whatsoever are available. However in 30 BC, during the building boom under Augustus, Statilius Taurus donated to the city a stone amphitheatre [3]. This (which might be called after its benefactor the first *bull-ring*) became the usual place for gladiatorial contests and animal displays during the reigns of Augustus, Tiberius, Caligula and Claudius [4]. In AD 39 Caligula started construction of a new amphitheatre [5], but nothing was completed until the flavian building, dedicated by Titus in 80 [6]. Outside of Rome, the case of Pompeii needs to be investigated since that city seems to have had a large amphitheatre as early as republican times [7], perhaps serving as a model for the later roman ones.

Afterward, particularly during the second century, many other amphitheatres were built throughout the empire [8]. They may be found for example at Lugdunum (Lyons), Milan, Capua, Verona, Puteoli (Pozzuoli), Pola (in Istria on the Gulf of Venice), Tarraco (Tarragona), Italica (Seville) and Thysdrus (El-Djem, south of Tunis). During Hadrian's time or later, very interesting examples were erected in Nemausus (Nimes) and Arelate (Arles). There even seems to have been a small one at Ventimiglia and another at Augusta Rauricorum (Augst in Switzerland).

Vespasian was prompted by the earlier unfulfilled wish of Augustus [9] to build an arena. The unrest under the three minor emperors following the mismanagement of Nero had brought the Flavians to power in AD 68. Vespasian peacefully closed the temple of Janus in 71 and with his son Titus produced the great Jerusalem triumph in 72. The reign of Titus started with the eruption of Vesuvius in August of 79 and the terrible roman plague and fire in 80. Outward signs of stability and of the permanence of the new rulers were in order,

The FLAVIAN AMPHITHEATRE was placed by its unknown architect on the site of the lagoon of Nero, adjacent to the Domus Aurea, sometime between 75 and 80 (although additions, some major, were made over the next two centuries). To the north of the site is the Equiline, with the Oppian to the northeast, and the Caelian to the east and southeast. Due west is the Palatine and at its foot the arch of Constantine on the Via Sacra. Near this point, next to the site of the arch, stood the colossus of Nero [10], lending its name to the amphitheatre. The historian Bede mentions the name in the 8th century:

*Quamdiu stabit coliseus stabit et Roma:
Quando cadet coliseus cadet et Roma!*

The exterior of the amphitheatre, of travertine limestone, is remarkable. The outer wall, eventually four stories, stood nearly 160 feet from the platform. Originally, the first three floors were:

Ground	Doric order	41 ft
First	Ionic order	39 ft
Second	Corinthian	40 ft.

The fairly rare Doric order was used to frame the 80 entrance arches, the Ionic copied the ground level of the Augustan Theatre of Marcellus, and the Corinthian had been used in particular on the portico of the Pantheon.

The original three floors had double ambulatories circling the entire building, and on the upper floors the facade was pierced by 80 archways. The interior vaults of ambulatories and stairways are concrete; local tufa was used throughout. On the ground level 80 arches served as entrances to the seating and to the arena, and were numbered on the keystone, beginning at the south central arch, labeled here as S, so that "I" stood just east of that and the numbers continued around to "XVIII" next to the axial arch E, then on northward with "XX" through "XXXVIII" at central arch N, again "XXXVIII" through "LVII", then axial arch W and finally "LVIII" to "LXXVI" on the west side of E. S seems to have been the imperial entrance, N may have been used by senators and by the sponsor of the day's games, while E and W were sometimes styled "Life" and "Death", used for the entrance of the gladiators and for the removal of refuse and bodies.

Because earthquakes and extensive quarrying have carried away the west facade today there remain only arch E and 32 entrance arches (viz. "XXIII" through "LIII"). The first two of these have been walled shut since the shoring up done under Pius VII (1800-1823). Direct measurement (on outer centres of the Doric pilasters) shows that the remaining 32 arches are 22'6" wide (with a std dev of 1 inch), and that arch E is 24'3" [11]. The outermost perimeter would thus have been very nearly 1800 ft.

The same measurement on the next piers inward (on centres facing outward) seems to yield very approximately 20'9". The outer ambulatory ringing the whole building has roughly 16 feet of clear way, but the width is 24 feet on centres of piers. The massive exterior piers on the ground level are about 8 by 11 ft. The Doric pilasters extend about 23 inches from the outer surface.

Opposite entrance archways XXIII and XXVIII are five bollards, roughly 50 ft out from the building on the edge of the level base surrounding the building [12]. On centres, they are separated by 14'6", 14'6", 13'11" and 13'8", but they are no longer plumb and their positions have certainly shifted. These might have been used by the crew of marines in setting up the *velarum* or awning, mentioned by Suetonius [13] in connexion with the older amphitheatre. The top or third story has fittings for pylons to bear the block-and-tackle required.

The major axis EW is actually oriented 23° N of W. The lengths of the major and minor axes have been given any number of times, and with an astonishing range of values. Seldom is the nature of the measurement explained, that is, from where to where. Bannister Fletcher uses the outer surfaces of the external piers (neglecting the pilaster) and finds 620 ft and 513'5"; Wilson-Jones 1993 finds 620.4 and 513.1 ft for the same measurement. These values seem reliable.

Without sorting out reliability, here are some examples from primary, secondary and even tertiary sources (many reduced here to feet from measurements in metres [14]):

The Exterior:

<u>Source</u>	<u>Major</u>	<u>Minor</u>
B Fletcher, 1943	620.0	513.4
Colliers Encycl	620	513
Encycl Britannica	620	513
G Lugli, 1960	617	513
Poster (Arles)	617	512
R Rea	616.8	511.8
J Durm, 1905	616.04	510.62
G Cozzo, 1928	616.04	510.62
L Friedlander, 1992	615	510.5
T F Hamlin	615	510
J B Ward-Perkins, 1970	615	510
Encycl Ital	613.5	508.5

Determining the measurement of the arena itself is at least as difficult. The entire floor is missing, leaving the yawning basement chambers, and the original boundary wall has been changed. The arena is surrounded by a *podium*, a narrow shelf upon which the senatorial boxes were arranged; the back wall of this podium makes a convenient benchmark. However, the axes of the arena are given in the literature with scarcely a reference to benchmarks. Wilson-Jones 1993, with some reservations, provides 271.0 and 163.7 ft, measuring to the face of the podium.

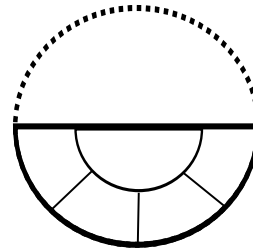
The Arena:

<u>Source</u>	<u>Major</u>	<u>Minor</u>
B Fletcher	287	--
Encycl Britannica	287	180
G Lugli	283	178
R Rea	282.2	177.2
J Durm	281.4	175.9
L Friedlander	281	177
Hamlin	281	177
Ward-Perkins	280	--.

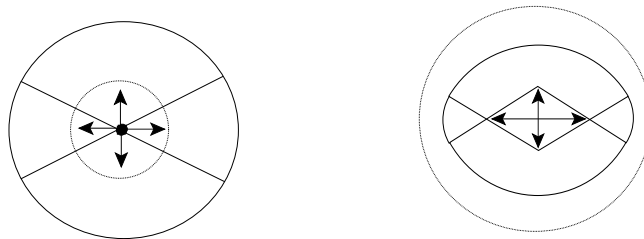
The Design.

The unknown genius chosen by Vespasian to build his monument and to replace the by-then ancient augustan amphitheatre was driven by the need to make a majestic statement in stone based on a simple design which could bear these grand dimensions. We will show that the design would be in the repertoire of any civic architect in the empire.

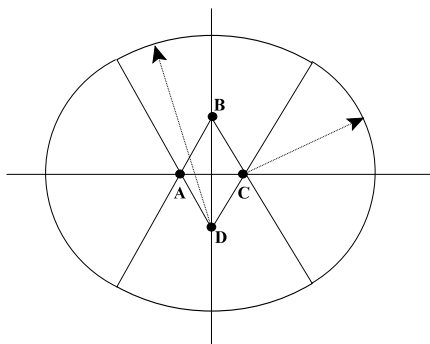
Pliny [15] claims that in 50 BC, to commemorate his father's death, C Scribonius Curio had the first *amphitheatre* erected, made of wood and consisting of two revolving parts so that it could first serve as theatre and then as amphitheatre. Operating such a contrivance would be quite a task. This is one of those confused, practically contradictory accounts, not uncommon in ancient translations. It may be nothing more than an allusion to the *design*, made up of rotated arcs and sectors derived from the simpler architecture of theatres; that is, the description may have followed a view not of the building itself but rather of the architect's drawings.



A roman (or greek, for that matter) theatre is generally a semicircular building with parallel seating and radial aisles established by a single centre, situated of course on the stage. There are dozens of extant remains, such as Caesarea, Lyons and Arles. The design itself is pure simplicity [16]; a problem in theatre building is finding a site in which the underworks supporting the seating might be replaced by a convenient hillside.



If a circle be divided into four parts by two diametres and two of the opposing sectors had shortened and equal radii, the four sectors, each designed as a part of a theatre, may then be rearranged into a *quadrarc*, with the centres of the constituent sectors forming a central rhombus [17]. Now the construction of parallel rows of seats reduces to the same simple problem as for the theatre.



The remains of the Theatre of Marcellus, built by Augustus in 11/10 BC to honour his son, strongly indicate that it served as a model for the outer facade of the flavian amphitheatre, strengthening the notion suggesting a theatrical design overall; that is, four copies of sectors of the Theatre could be combined to form the amphitheatre, following Augustus' lead in two ways.

To be explicit, we may describe briefly the layout of the design [18]. Whether adhering to the traditional length of a stadium, or using an aesthetic principle unknown to us, the architect laid out a line to serve as the "major axis"; a perpendicular line through a central point O served as "minor axis". He set two points A, C on the major axis 75 feet from the central point O and two further B, D on the minor axis 100 feet from O. ABCD with sides of 125 feet serves as the *rhombus* of centres mentioned above. Using the points A and C and a radius of 225 feet the architect traced the two end sectors with an axis of $600 = 225 + 225 + 75 + 75$. Using B and D and a radius of 350 feet gives the lateral sectors with an axis of $500 = 350 + 350 - 100 - 100$.

All of these share a common unit of 25 feet and so the measurements may be stated in construction units u :

major semi-axis	$12u$
minor semi-axis	10
first radius	9
second radius	14.

It hardly needs mention that the *feet* used in these measurements are neither english feet nor the standard roman foot. Since the actual measurements of the building are available only to within rather generous margins, it is necessary to leave these measurements in *vague feet* of perhaps 12.4 english inches.

Just now we discover that the central rhombus has sides of $5u$ with diagonals of 8 and 6, so that it is made up of four right triangles having sides 3-4-5. This triangle is known to have been used in construction since ancient times.

The arena is laid out in a similar fashion. Using centres A, C and a radius of $2u$ gives the end arcs, while B, D and a radius of $7u$ gives the lateral arcs. The fit with actual measurements is not perfect, but is suggestive.

Now using elementary geometry, the four circular arcs (measured in u units) are found to be 18 for the two larger lateral ones and 16.7 for the end ones. The total is 69.4 which is distributed over the 76 smaller entrances and four larger. The smaller ones are seen to be 0.86 units in width.

Conclusion.

Returning to the original problem, we sometimes find in references to the Flavian Amphitheatre that the drawing of the plan has some indication of having been assembled from circular arcs and none that it was drawn as an ellipse, although the text itself may maintain that the building is *elliptical*. Fontana and Neralco 1725 suggest a quadrarc construction, at least for the drawing of the plan. Nibby 1819 uses an 8-arc design copied by Cozzo 1928 in *Roman Engineering* (the match with the actual building is both complicated and not entirely satisfactory).

The comparison of the quadrarc with the ellipse having the same axes shows that the differences in the cases of moderate eccentricity are far, far below the precision of vulgar measurement. For example, the area enclosed by the arc construction compared with that enclosed by an ellipse on the same axes has an error of about 0.4%. In other words, the approximation to an ellipse by the appropriate quadrarc (based on the same axes) is so good as to be undetectable.

The ability of roman engineers to lay out complex plans based on circular arcs is manifest, for example, in the design of the Pantheon, with an interplay of circle and square, as well as of the hadronic villa at Tivoli in which the compass plays a rôle of breathtaking virtuosity [19].

One final point about the plausibility, rather than the practicality, of the quadrarc design for the Flavian Amphitheatre, may be given. Consider that it is well-known that the emperor's box on the podium was 100 *vague feet* from the central point of the arena (matched on the other side by the box reserved for the sponsor of the games). This puts the emperor's seat just on the centre point of one of the lateral circular sectors, and so is the literal *focus* of all the seats on the opposite side. In fact, today, at a viewpoint in front of the iron cross standing near that spot, one may see the 23 entrance archways (most still extant) converging precisely on himself. That is to say, the emperor's box is a precise cynosure of the building. Such an accomplishment would suit an imperial architect.

Notes.

[1] Figure.

[2] "He gave entertainments of divers kinds...in the gladiatorial contest in the Forum Gurius Leptinus.... The game of Troy was performed by two troupes, younger and older boys. Combats with wild beasts were presented on five successive days.... To make room for this the goals were taken down and in their place two camps were pitched. The athletics competitions lasted for three days in a temporary stadium built for the purpose in the region of the Campus Martius." (*Deified Julius xxxix.* Gaius Suetonius Tranquillus. *De Vita Caesarum*, translated by J C Rolfe.)

[3] "More than that, he often urged other prominent men to adorn the city with new monuments or to restore and embellish old ones, each according to his means. And many such works were built at that time by many men; for example, ..., an amphitheatre by Statilius Taurus...." (*Deified Augustus xxix.* Suetonius.) This structure was probably destroyed in the neronian fire of 64.

[4] "He (Augustus) gave ... combats of gladiators not only in the Forum or the amphitheatre, but in the Circus and in the Saepta.... He gave athletic contests too in the Campus Martius, erecting wooden seats." (*Deified August xliii.* Suetonius.)

"He (Tiberius) gave a gladiatorial show in memory of his father, and a second in honour of his grandfather Drusus...the former in the Forum and the later in the amphitheatre." (*Tiberius vii.* Suetonius.)

"He (Caligula) gave several gladiatorial shows, some in the amphitheatre of Taurus and some in the Saepta." (*Gaius Caligula xviii.* Suetonius.)

[5] "He likewise began an aqueduct in the region near Tibur, and an amphitheatre beside the Saepta; the former finished by his successor Claudius, while the latter was abandoned." (*Gaius Caligula xxi.* Suetonius.)

[6] "And yet he was second to none of his predecessors in munificence. At the dedication of the amphitheatre..., he gave a most magnificent and costly gladiatorial show." (*Divus Titus vii.* Suetonius.)

[7] A colony of veterans was established by Sulla at Pompeii in 80 BC. As early as 70 BC they had built an amphitheatre. With a ten-year closure as a punishment for the riots of AD 59, the building withstood the earthquake of February 62 and lasted until the cataclysm in August 79. (Cf J Ward-Perkins, *A Claridge. Pompeii AD 79.* 1978)

[8] Golvin 1988 and Wilson-Jones 1993 give particularly detailed accounts of the various designs and locations of amphitheatra in the Empire.

[9] "He also undertook new works...an amphitheatre in the heart of the city, a plan which he learned that Augustus had cherished." (*Divus Vespasianus. ix.* Suetonius.)

[10] The 100-foot bronze was done by Zenodorus. Hadrian moved it from the Oppian down to the amphitheatre. Constantine finally demolished it.

[11] Measurements of the extant exterior archways were made by the author in June 1992.

[12] Lanciani 1897 has the width of this platform as 57.4 ft wide

[13] "At gladiatorial shows Caligula would sometimes draw back the awnings when the sun was hottest and then give orders that no one be allowed to leave." (*Gaius Caligula. xviii.* Suetonius.)

[14] The extraordinary result given in Durm provides the length of the two axes to the nearest millimetre!

[15] *Natural History.* xxxvi.116.

[16] Figure.

[17] Figure.

[18] Figure.

[19] See Jacobson 1986 for a full account.

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Bethlehem, July 1992
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