Foundations and wall structures in the basement of the Colosseum in Rome

Heinz Jürgen Beste

Following a generous offer made by Rome's Archeological Superintendence, the German Archeological Institute in Rome commenced an investigation of the construction details of the arena and the basement of the Colosseum in 1996. The Colosseum forms part of a series of well preserved major structures of antiquity whose state of preservation is inversely proportional to our knowledge of the history of the building.1

The ultimate aim of the work we have commenced is to distinguish the multitude of building phases that followed each other in the five centuries in which the world's largest amphitheatre was in use.2 Moreover, it is proposed to attempt design reconstruction based for the first time on a thorough cataloguing of building details and history. The Superintendence also expect a proposal for using the basement as a museum, as also for the restoration of the arena floor.

The basement of the amphitheatre, which several walls subdivide into a series of corridors, measures 76.12 m along the longitudinal axis of the oval and about 44.07 m along the shorter transverse axis. It is delimited by the so-called encircling wall, which in its day carried the podium. Constructively this wall is the counterpart of the so-called foundation wall which supports the outer facade. If one today approaches the edge of the arena from the stands, one looks down at the basement, because the wooden arena floor has long since disappeared. The longitudinal axis of the oval-shaped basement is oriented in the East-West direction, and this is also true for the greater part of the walls one finds there. These walls, made of tufa blocks and bricks, subdivide the basement into twelve corridors of different widths and lengths and, more precisely: six elliptical corridors that run parallel to the encircling wall and nine corridors parallel to the longitudinal axis (fig. 1).

PHASE I

At the beginning of our investigations attention was concentrated on distinguishing the individual building phases and, more particularly, the tufa walls, because these divide the basement into the aforementioned corridors. For this reason I shall henceforth describe these tufa walls as Phase 1. As reconstructed on the basis of our building records, this phase is characterized by a very light but long-spanning construction. The walls, which are about 90 cm wide and 6.30 m high, attain arch spans of up to 4.0 m. These filigree walls made of tufa, which are set between 2.0 and 4.0 m apart and carried the wooden arena floor, were presumably at first underdesigned for withstanding the vibrations caused by earthquakes, ground subsidences and perhaps the games themselves and therefore had to be subsequently stabilized, as is clearly brought out by our findings (fig. 2).
PHASE II

For this reason all the openings in the arches were reduced by inserting brick arches 60 cm deep within the existing ones. What is particularly noteworthy about this work is that the soffit was covered with sesquipedales and bipedales, thus making it possible to use falsework instead of complete centering. At the same time as the arches were consolidated, all the openings and passages were narrowed by providing each soffit with a strong brick pillar (c.60 x 60 cm). The only reason why we assume that the walls numbered 4 and 11 belong to phase II is that they are made out of brickwork with a basic tufa layer. I suppose therefore that in phase I there may have been wooden piles instead of the walls 4 and 11. There are numerous square structures in the basic tufa layer which I believe functioned as the pile holes for this wall. For reasons of construction the walls 4 and 11 could not have been built at a later stage as they support walls belonging to phase III.

PHASE III

This phase consisted of stabilization involving all the walls. It repeated the procedure of phase II by adding masonry in all the passages, which were thus further reduced in size. The tufa walls in corridors C, E north, E south, G north and G south were each reinforced by the addition of brick walls rising to a height of c.3 m; they were joined to each other by means of transverse arches and thus gave rigidity to the original walls (fig. 3).
PHASE IV

Phase IV constituted a very substantial alteration of the existing subdivision of the basement because it involved the erection of a brick wall (c.2.3 m high) in corridors F north and F south that closed off the greater part of the passages that served them. This phase is distinguished from all the others by the fact that it does not consist of bricks of uniform size and rests on a pediment made of material that must have fallen down from the top of the walls.

Theoretical treatises about technical details or traditions regarding the design and dimensioning of foundation are not to be found in the literature of antiquity. Vitruvius, who provides us with quite a few constructional details, dedicates a brief subchapter to the theme, but never really comes to grips with the problem.³

The state of research of modern times reflects the lack of interest of the classical authors. Every description of the building speaks of the foundation and the manuals do of course provide an summary overview of the various solutions, but fight shy of a true analysis of the problem.⁴ Though the foundations are literally fundamental for every building structure, only a few papers have hitherto been dedicated to this theme.⁵ And this notwithstanding the fact that some classical authors speak of building failures during construction due to inadequate foundations.⁶

The fact that the foundation is the sole part of a building that cannot be designed by means of permanent correcting trials during construction shows us that the problem must be considered to have been solved in the case of the monuments that are still standing today. Although considerable interest has always been shown in the structural concept and the
static safety of the Colosseum, the state of our knowledge about the foundations of the building is very scant. Presumably the surviving ancient structures and especially the Colosseum suggest a stability and durability such as to make us tacitly assume that they are adequately founded.

In his book entitled *Ingegneria romana* (1927), Giuseppe Cozza was the first author to consider the problem of the foundation of the Colosseum. According to his concept, which he developed in the light of the structure of the eastern gallery (38), the 80 walls that carry the roughly 50 m high superstructure and cavea of the Colosseum do not stand on a foundation platform, but rather on strip foundations made of *opus quadratum*, each roughly 3 m wide and reaching down to a depth of about 6 m. In order to assure a solid support and thus enhance their carrying capacity, these eighty strip foundations—in the opinion of the author—are joined by transverse arches, while the space between them has been backfilled with soil.

For a long time the theory formulated by Cozza about the structure of the Colosseum's foundations was neither doubted nor checked, and it was only in 1977 that a trial boring executed in the area of the outer circumference showed that the foundation consisted of *opus caementicium*, and not *opus quadratum* as had previously been assumed.

The reconstruction of the arena floor commenced in the year 2000 brought with it the possibility of sinking six sampling cores in the basement to clarify the foundations on which it rested. Three of these were situated in walls 7, 8 and 13 (S1–3) and a fourth in corridor H (SA). A further trial boring was carried out in niche 39 (SB) and yet another (SC) between niches 15 and 16. The latter, however, was horizontal rather than vertical (fig. 4).

The results of borings SB and SC, considered...
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Figure 4
Section through the shorter transverse axis from the Colosseum

together with those of the 1977 trial, made it possible for the first time to make some concrete statements about the construction process and the size of the foundations. Accordingly, the walls in the basement would seem to have a separate foundation, while the façade and the cavea of the Colosseum rest on a foundation ring made of opus caementicium that is about 60.30 m wide and 12–13 m deep. The manner in which it was constructed permits its being subdivided into two sections. The coring results show that the shallow footing of the ring is situated at a level of 10.0 m asl. Section I of the foundation rises from this level and reaches up to about 16.0 m asl. It is now documented that it was constructed with the help of timber shuttering, which actually be seen in the basement at a distance of about 0.50 m below the upper edge of this first section. Section II of the foundation reaches from about 16.0 m asl to about 22.0 m asl and is lined both on the side of the façade and on the inside (i.e. in the area of the basement) by a 2.30 m wide brick wall, the so-called inner and outer encircling walls. From the construction point of view, the fact that different techniques were employed for the two sections means that the lower section must have been built below ground level and with the help of formwork.

To permit the construction of the two encircling walls, on the other hand, the surrounding ground must either have been excavated down to level 16.0 m asl or must not have risen above that level in the area in which the Colosseum was erected, our state of knowledge suggesting the latter assumption to be more probable. This assumption is also confirmed by ongoing excavations, which show that the level of the buildings destroyed by the fire of 64 A.D. is of the order of 15.50 m asl and therefore lies only some 0.50 m above the floor level of the Colosseum basement.

The result of the horizontal boring SC through the inner encircling wall made it clear once more that the brick wall, quite apart from its architectural articulation into 40 niches, performs first and foremost a structural function. The wall sections between the niches, 1.80 m wide by 2.30 m deep, act
as buttresses or counterforts and therefore enable the brick wall, which within the niches has a thickness of no more than 0.72 m, to resist the pressure of the foundation ring between 16.0 m and 22.0 m asl. Whether the outer encircling wall is constructed in the same manner has to remain an open question for the moment, because so far our knowledge is limited to its uppermost layer.

Trial borings S1 and S3 in the basement of the Colosseum showed that walls 7 and 8 stand on strip foundations that are dug into the ground of the basement and have a width of about 3.25 m. The material contents of the two cores enable us to distinguish two sections of these strip foundations. Section I, which has a depth of about 3.25 m and extends between 12.75 and 15.50 m asl, is made of opus caementicium and is topped by a layer having a thickness of the order of 25–50 cm, the so-called levelling course (16.0 m asl), likewise made of opus caementicium. The contents of core S3, which reached down to 11.20 m asl for an overall length of 4.80 m, consists exclusively of opus caementicium, but in this case the levelling course cannot be demonstrated. The results of the two borings are very clear and show that the 6.0 m high walls in the basement rest on foundations having a depth that varies between 3.25 and 4.80 m and are therefore adequately founded. The borehole in corridor H (SA) showed that only the levelling course was poured there and that it has a thickness of about 50 cm (fig. 5).

The archaeological investigations undertaken at the same time made it clear that the structure of the foundations in the basement is considerably more complex than is suggested by the results of the coring. Four of these (S1, S6, S19 and S 27) are of particular interest; they brought to light wooden residues along the strip foundations and thus made it possible to conclude that these must have been constructed within 4–5 cm thick timber formwork, which — given the high water table in this area, has been well preserved to this day.

Though the high water level prevented the boreholes from reaching a really substantial depth, they showed that the strip foundations of wall 1, 5, 6 and 14 consist of three sections, which contrasts with those of wall 7 and 8, which consist of only two sections. The layer of opus caementicium (US 635) is followed by another layer of opus caementicium, though in this case having a different composition. The upper layer has the same width as the lower one, but its height varies from one wall to another. Just as in the case of walls 7 and 8, it is topped by a levelling course (US 629). Having a thickness of the order of 10–15 cm. It is not clear why the structure of the foundations should vary from one wall to another. All I can do is to suggest that the subdivision into several sections might be due to unevenness of the terrain in the basement area. Presumably the lower section of opus caementicium was in each case at first brought up only to the level of the adjacent ground. The levelling was then obtained by means of the second layer of opus caementicium poured on top of the first, so that the height of the second layer must have depended on the ground level. The levelling course, which covers the entire area, i.e. both the corridors and the strip.

Figure 5
Detail plan and section through the shorter transverse axis of the basement
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...foundations, then brought the structure up to 16.0 m asl, the desired floor level for the basement. Since the foundation section made of opus caementicium of walls 2 and 13 neither has a so-called cement-gravel bedding nor is topped by a levelling course, it seems possible that these two foundations might have served as level marks. They presumably also served to define the location and direction of the other foundations, since these —following the pouring of the levelling course— were no longer exposed to view.

CONCLUSIONS

The roughly 50 m high superstructure/ façade and the cavea of the Colosseum rest on a foundation ring consisting of some 246,000 m³ of opus caementicium. The enormous mass of the foundation seems to be adequately dimensioned, because parts of the southern side of the structure collapsed only in the 12th century, presumably as a result of strong earthquakes. The fact that the thesis according to which the Colosseum rested on strip foundations of opus quadratum, though formulated in 1927 without a detailed investigation, had to wait 50 years before it was corrected is indicative of the limited interest that is still being dedicated to structural problems, and this notwithstanding the fact that they are altogether elementary for the building in question.

Furthermore, recent data about the structure of the foundations and knowledge of the street level of the buildings that previously stood on the site of the Colosseum enable us to make the following hypothetical statement about the Colosseum area. Unlike the western side of the valley, it would seem that this area was not redeveloped after the fire, because otherwise the second section of the foundations with the two encircling walls could not have been constructed in this particular manner. That the area kept clear of the housing reconstruction undertaken by Nero, which reached levels up to about 20.0 m asl, might have been constituted by the stagnum Neronis seems plausible from a constructional point of view and would partially explain the short time it took to put up the Colosseum, because no excavation work would have had to be undertaken from this level down to 16.0 m asl. However, our knowledge of the level relationships between pre-Neronian buildings and Nero's reconstruction in the area around the Colosseum is as yet extremely scant, so that a more precise concept of the size and location of the stagnum will have to await the drilling of further trial holes.

NOTES

1. For the history of the Colosseum see Parker 1876; Rea 1996; La Regina 2001. For the gladiatorial combat and games see Golvin and Landes 1990. For the amphitheatres see Golvin 1988; Wilson Jones 1993.
3. Vitruvius I 4, 2.
7. Cozzo 1927, 204 ff., fig. 133; idem, 1977, 20 ff., fig. 12; Lamprecht 1987, 155 ff., fig. 150.
8. Mocchegiani Carpano 1977, 10 ff., figs. 2, 6; idem, 1985, 122 ff., fig. 1.

REFERENCE LIST

Colagrossi, P. 1913. L’Anfiteatro Flavio nei suoi venti secoli di storia (Roma).
Cozzo, G. 1927. Ingegneria romana (Roma).
Durm, J. 1885. Handbuch der Architektur Bd. 2 Die Baukunst der Römer (Karlsruhe).


La Regina, A. 2001. *Sangue e arena* Catalog (Rome)


