CHAPTER 6

The Reinforcement System of the Theban Treasury in Delphi

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1 Introduction

The Theban Treasury was built in the fourth century BCE in the sanctuary of Apollo at Delphi. Upon excavation, a curious reinforcement system was found in its foundations that has sparked discussion throughout the last century. It consists of channels cut across foundation courses, which accommodated frames reinforcing the structure. This specific arrangement seems to be unprecedented and does not find any direct parallel in the Greek world in that period. The apparent singularity of the frames of the Treasury, often underlined by the commentators, suggests that it was an innovation of the time. Perhaps because it was designed to respond to structural problems specific to the Theban Treasury, it was apparently not used again in later constructions, at least in this specific form.

This chapter looks at the notion of 'anchoring' through the lens of this specific feature of the Theban treasury at Delphi.[1] It starts with a brief description of the treasury and the structural problems that it faced due to its peculiar location. This is followed by a thorough overview of the scholarly discussion on the reinforcement system found in the foundations of the treasury. I then give new arguments for the identification of the material used to fill the channels and address the question of their structural role, using parallels from various periods. Drawing on these observations, I finally discuss the context in which the frames were conceived, in an effort to position this innovation (if it indeed was one) in its technical and cultural background. By doing so, I show how this seemingly unique device was, in fact, anchored in a long tradition of craftsmanship.

1 Sluiter 2017.

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2 The Theban Treasury in the Sanctuary of Apollo in Delphi

The Treasury of the Thebans was erected in or shortly after 371 BCE, funded by the spoils of the battle of Leuktra.[2] It was located in the south part of the sanctuary of Apollo, close to the southwestern entrance. The building was facing west and was the first monument one could see on their right-hand side upon entering the sanctuary from that entrance. One of the largest treasuries of Delphi (12.33 × 7.22 m), it was a Doric building with a sober aspect and limited decoration, in line with fourth-century architectural developments of the Doric order. The elevation was made exclusively of a local, greyish limestone from the Profitis Ilias quarries, while poros was used for the foundations. Instead of having the usual distyle in antis plan with two columns in between anta walls in the front, the façade consisted of a plain wall pierced only by a door and by a small rectangular window on top of it. Inside, the space was divided between a pronaos and a cella. The krepis, made of three levels, rested on three courses of foundations, which were themselves laid on top of a footing course.[3]

The Treasury was so close to the south end of the sanctuary that it was actually resting on and overhanging the south peribolos wall, at a height of about four metres above the level of the road below. The exact way in which the building was articulated with the wall is difficult to determine because much of this part of the wall had collapsed leaving only parts of the northern foundations in situ at the time of its discovery. The southwestern part of the peribolos wall had been destroyed before the erection of the Treasury. Indeed, the Theban monument was located within a portion of the wall that had been remade, probably at the same time that the Treasury was built. This new section was constructed at least in part with poros blocks from the sixth-century Alcmeonid temple of Apollo, which had been destroyed in or around 373 BCE.[4] As A. Jacquemin and D. Laroche have put it, it is as if the peribolos wall had

2 Paus. 10.11.5. Diodorus speaks of a *naos* dedicated by the Thebans from the Phokian spoils (Diod. 17.10.5). While some consider that he was referring to the treasury and attributed it to the wrong period and occasion (Bommelaer and Laroche 2015, 156), others, like Dinsmoor (1912, 452) have suggested that Diodorus indeed referred to the Treasury of the Thebans and that his account was right, which implied that it must have been built after 346 BCE and the end of the Third Sacred War. P.J. Rhodes (2019, 52) thought that it is unlikely since, although Thebes was on the 'winning side', it was exhausted at the time.

3 The description of the building is based on the monograph of the Theban Treasury by J.-P. Michaud (1973) and the article by A. Jacquemin and D. Laroche (2012, 106–114).

4 See Rougemont 2013, n. 14, on the date of 373 BCE.

been replaced, in this area, by the foundations of a building.[5] The peculiar location of the Treasury, dictated in part by the lack of space in the sanctuary and in part by the desire of the Thebans to take a prominent position,[6] created several structural challenges for its builders. Not only did they have to deal with the steeply sloping terrain, but they also had to preserve the building from earthquakes and landslides, which were not uncommon in the region. It seems they designed the foundations of the treasury in response to these threats, and they probably did so with the recent catastrophe of the 370s in mind.[7]

3 The Channels in the Foundations: Description and Historiography

The poros foundations of the treasury consisted of three courses of ashlar. Some of the blocks of these foundations present, on their bedding surface, a single cut for a channel running from one end of the block to the other. The channels were cut at a distance of about 0.5 m from the outer ledge and their section is 7.5 cm deep and 10 cm wide. At least one corner block, still in situ, has two channel cuts crossing at an angle. Therefore, although not all foundation blocks are preserved, it is safe to say that the channels ran on all four sides of the two upper foundation courses (fig. 6.1). Hence, these channels evidently served to accommodate bars made of another material than stone.

The unusual character of these grooves has attracted much interest from scholars since the time of their discovery. Karo was, in 1910, the first scholar to comment on the channels and their function; he imagined that they had hosted 'pipes' ('tuyaux') made of lead, but could not fathom the function of such pipes.[8] The subsequent year, Bourguet relayed the observations made by Replat, who pointed out the crossings of the channels at the angle blocks and imagined that the grooves, instead of lead pipes, had contained wooden beams, and that these had been intended to increase the overall stability of the construction.[9] In the same year, the German scholar Pomtow published a similar interpretation, adding that the wooden beams ran along all four sides of the two upper courses of the foundations. He based this comment on the

5 Jacquemin and Laroche 2012, 111.
6 On the political and ideological implications of the location of the Theban Treasury, see Jacquemin and Laroche 2012, 111; Scott 2017.
7 Thély 2016, 251–255. Perrier 2021: 64–65.
8 Karo 1910, 190 n. 1.
9 Bourguet 1911, 160.

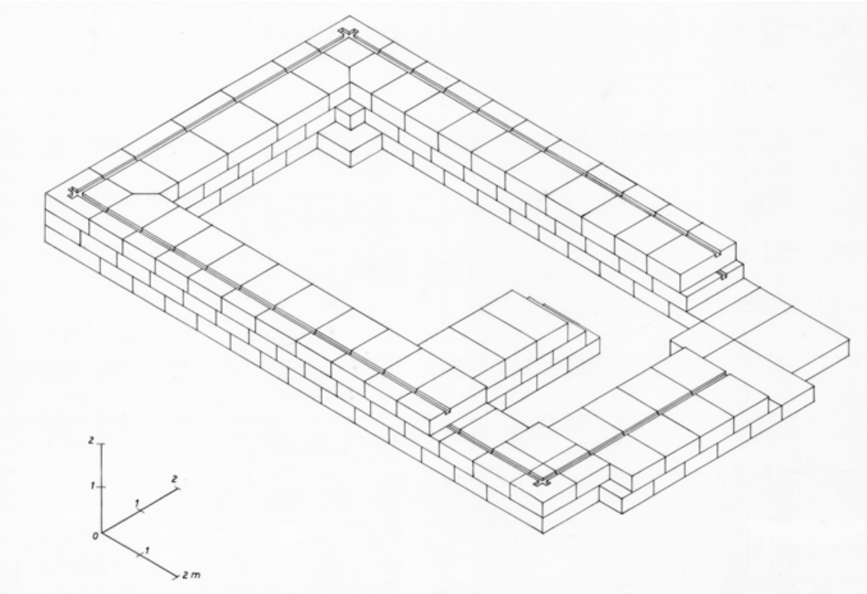

FIGURE 6.1 Axonometry of the foundations of the Theban Treasury (Michaud 1973, pl. 61 EFA/J. Blécon, 1970)

crucial information, found by Bulle, that a corner block of the krepis bore a faint imprint of the beams on its resting surface.[10]

In 1912, Dinsmoor discarded the ideas that these grooves had been used for wooden beams, arguing, conversely, in favour of iron bars. Dinsmoor's argument was based on the assumption that wood was not resistant enough for the intended purposes of the bars: wooden beams of 12.5 m long and 8 cm thick, he thought, could not have sustained such pressure. Furthermore, he pointed out that the angle blocks with the imprints on their resting surfaces presented dowel holes located in the area of the imprints, meaning that these blocks were dowelled not to the upper blocks of the foundations but, rather, directly to the frame. Dinsmoor claimed that such a system was not possible with wooden beams but he did not go any further in explaining why. Finally, his argumentation rested on two alleged structural uses of iron at the Propylaia at Athens and at the Olympieion of Acragas.[11] In a 1922 article on the use of iron reinforcements in Greek construction, Dinsmoor reiterated his idea that the groove had hosted an iron girdle, although he admitted that nothing remained of the bars. He also insisted that the fact that the limestone walls were dowelled to the

10 Pomtow 1911, 1613–1615.

11 Dinsmoor 1912, 454–455.

bar proved that it was made of iron, again without being any more specific in his arguments.[12]

The 1922 article by Dinsmoor remains often cited today and was an authority for at least several decades, to the point that two major twentieth century handbooks of Greek architecture, by Orlandos and by Martin respectively, retained the idea that the foundations of the Theban treasury were held together by an iron girdle in the foundations.[13] However, as these handbooks were being published, some scholars were expressing doubts about Dinsmoor's interpretation and, more generally, about the actual usefulness of iron reinforcements. In a mostly overlooked 1957 paper, Hamilton, an engineer interested in civil engineering history, reviewed the examples of structural iron discussed by Dinsmoor and questioned the idea that iron bars would have been of massive, solid construction.[14] He stressed three weaknesses in Dinsmoor's argumentation: first, the absence of any remains of iron apart from iron dust; second, the fact that these iron structures had not shattered the stone blocks when rusting away; third, the fact that such massive forgings required either an impressive labour force or an advanced technology for which no compelling evidence has survived. These are *ab silentio* arguments, but they do highlight the fragility of Dinsmoor's interpretation.

In 1973, in his monograph on the Treasury of the Thebans, Michaud offered the alternative possibility that the grooves had contained a wooden girdle. His arguments were as follows. First, iron bars would have been covered with lead, but no trace of lead or oxidation remains. Second, the other examples used by Dinsmoor to support his theory pertain to very different parts of the buildings, and in no case to the foundations. Third, the making and adjustment of such iron bars, with several mortises at the angles for vertical dowellings, required considerable means and advanced metallurgy techniques that are not inconceivable for the Propyleia of Athens but seem out of proportions in the case of the Theban Treasury.[15] Contrary to Dinsmoor, Michaud did not see any problem of dowelling the blocks of the lowest krepis course to wooden beams.[16]

12 Dinsmoor 1922, 149–150.

13 Orlandos 1958, 20–21 (= Orlandos 1966, 112–113); Martin 1965, 157–158.

14 Hamilton 1957, 33–37. Instead of solid sections of iron, Hamilton suggested that the beams could have been formed of long flats nailed to a wooden core or riveted together.

15 Michaud 1973, 24–25.

16 Michaud 1973, 25 n. 1, 34. In his review of Michaud's book, Miller (1975) regrets that he did not discuss the problem of dowelling the euthynteria blocks (here understood as the lowest course of the krepis) in the wooden beams. However, Michaud simply did not consider it a problem (25 n. 1: 'rien n'empêchait cependant de sceller sur le bois tous les blocs courants de l'euthyntéria').

The French scholar also briefly discussed the function of the frames. He discarded water torrents as the risk having prompted the system because it would have made the foundations dangerously interconnected. According to him, the two main factors that had to be taken into account were earthquakes and differential settlements; the purpose of the frame was to limit the damage caused by these two factors. He did not, however, discuss the structural mechanics in detail.

Since then, the frames of the Theban Treasury have been mentioned on several occasions. In her handbook on Greek architecture, Hellmann reproduced Michaud's reconstruction drawing of the foundations of the treasury but only referred, although cautiously, to the theory that the beams were made of iron.[17] Jacquemin and Laroche, on the contrary, endorsed Michaud's interpretation in their recent reappraisal of the treasury.[18] Finally, Thély suggested that the main reason for implementing the frames was the risk of landslides, which could be triggered by both earthquakes and water torrents.[19]

4 Iron or Wood? The Material Used to Fill the Channels

Iron is technically stronger than wood, with better tensile, compression and shear strengths.[20] However, several arguments further support Michaud's interpretation of the frame as wooden beams. The first is in line with his claim that there was no trace of lead or oxidation in the channels. Lead is often missing from mortises that used to contain it and have been exposed, intentionally or not, in the course of the history of buildings. This metal can be recycled very easily and scavengers have little hesitated to scrape it off whenever they had the occasion to. The operation of removing the lead, however, rarely (if ever) goes without deteriorating the edges of the mortises. Such scars are visible on many ancient monuments.[21] They are absent, however, from the channels of the Theban Treasury, which supports the idea that lead, and therefore also iron, were not used in this case.

Another point that needs to be considered is the question of feasibility. This issue has only been touched upon briefly by Hamilton (see above). One problem in particular seems not have been asked, perhaps because it was deemed

17 Hellmann 2002, 109.
18 Jacquemin and Laroche 2012, 111.
19 Thély 2016, 255.
20 Wright 2005, 12.
21 Bernard 2009.

to be obvious: was each of the four beams made of a single piece of material, or of several assembled pieces? The question is all the more important when it is considered that the long beams were about 12.6 metres long. Arguably, single-piece beams would have been preferable, for structural reasons. Iron bars would have had to be assembled in one way or the other, as there was no way to produce a wrought iron bar of this length in one go; cast-iron technology, even if it existed at the time, was not nearly as advanced as to produce 12.6-meter long bars. Several iron bars, therefore, would have had to be riveted or welded to one another. Single timber elements of that size, however, were not exceptional. Structural wooden beams and masts regularly exceeded that length in antiquity.[22] And while there are many recorded examples of long timbers, no clear evidence—whether archaeological or literary—survives of very long iron rods.

Finally, the issue of the costs, even if difficult to address, must be taken into account. Treister has gathered various fourth-century price records for iron clamps and dowels and suggested that because such objects were relatively simple to manufacture, the price of iron itself must have been only slightly lower.[23] Particularly relevant is the price per talent as recorded in the building account of the Thymele in Epidauros.[24] The figure is quite consistent over time, as it is comprised between 14 dr. 4 ob. and 15 dr.[25] from years 11 to 20 of the construction, i.e. between 366 and 357 BCE, a date probably close to that of the Theban Treasury.[26] On the basis of these figures, on the one hand, and of the volume comprised by the channels (about 0.6 m^3) and, therefore, the weight of iron necessary to fill them (about 4.6 T), on the other hand, the price of iron can be estimated at 2139 dr.[27]

It is impossible to say for certain what type of wood would have been used in the foundations of the Theban Treasury, but we can make an educated guess based on the length of the longest beams (about 12.6 m) and their structural role. Three types of wood can be considered good candidates: pine, fir, and cypress. Pine and fir were considered the most suitable types of wood for

22 Meiggs 1982, passim.

23 Treister 1996, 250.

24 Prignitz 2014 inscr. nr 2 = *IG* IV^2 103.

25 Mathé 2016, 248 fig. 3; Prignitz 2022, 410.

26 According to the chronology by Prignitz 2014, 104–105; see also Prignitz 2022, 412. Mathé (2017, 138–139) advocates a more traditional dating of the Thymele around 360–320 BCE.

27 It should be noted that the prices for dowels and clamps are significantly higher in other buildings of Epidauros (around 1 dr. per mina), but all these constructions can be dated to the later part of the fourth century BCE (see Prignitz 2022, 410). Prices in Delphi in the second half of the fourth century BCE vary considerably; see Mathé 2016, 248 fig. 4.

construction in the ancient Mediterranean. Cypress was deemed to be one of the most durable types of wood and was used in temples mostly for doors and special features. Meiggs has shown, however, that it was likely used for roofing as well in some cases and, therefore, it is possible that it was used in the channels of the Treasury of the Thebans.[28]

As noted by Meiggs, the documentation on timber prices is often frustrating. Most of the time, only the length of the purchased timber is indicated in the accounts, while the species is rarely specified.[29] In short, we usually do not have nearly enough information to draw good estimate figures. However, in our case we are lucky enough to have some recorded figures for the purchase of cypress logs in 336/5 by the *naopoioi*, the building commissioners in charge of the Temple of Apollo at Delphi.[30] While no measurement is recorded, these logs must have been for the main beams of the temple's roof, with a length of about 12 metres. The average price per log was 132 dr.[31]

Considering how thin the sections of the foundation beams were, it can be assumed that one log represented enough material to make all four beams. In terms of raw material price, 132 dr. is more than ten times cheaper than our estimate for the price of iron, and it was perhaps much less, if pine or fir was used rather than cypress. Of course, one needs to add transportation costs on sea and on land (about 80–90 dr. per log in the case of the beams for the temple of Apollo),[32] with the additional difficulty of having to carry a long log of 13 metres or more from the port of Kirra all the way up to the sanctuary of Apollo. However, the log could have come from much closer, which would have arguably reduced the overall price.

Finally, there is the question of the cost of manufacturing of the beams. Whether they were made of wood or of iron, it is difficult to estimate such a cost, not only because it is a unique system but also because we have very few accurate prices recorded for wood- and ironworking. In the case of woodworking, a contemporary parallel is found in the building account of the Temple of Asklepios of Epidauros, where it is recorded that a craftsman took up to work on the roof truss for 490 dr.[33] Of course, the frames of the Theban Treasury were a whole different kind of work, but it is hard to imagine that their installation would have cost more than that. As for iron, any attempt at getting broad estimates for the cost of manufacturing bars made of that metal is even riskier,

28 Meiggs 1982, 200.
29 Meiggs 1982, 362–370.
30 *CID* II, 60.
31 Amandry and Hansen 2010, 445.
32 Amandry and Hansen 2010, 445.
33 Prignitz 2014 inscr. nr 1, l. 40–41 = *IG* IV^2 102, l. 42–43.

since the only known examples of structural iron (except clamps and dowels) that we know of are only recorded as negative traces in architectural remains. It is, however, worth reminding here the (arguably) rather limited capacities of the ancient Greek furnaces and the important amount of coal or firewood necessary to operate them. Clearly, from the perspective of the costs, the advantage must have been to timber over iron. However it is difficult to evaluate the cost of manufacturing the bars with iron, and whether cost would have been a deterrent for the Thebans, who benefitted from the spoils of Leuktra.

Overall, even if the use of iron cannot be discarded altogether, wood must be the preferred hypothesis: not only does it fit better with the archaeological remains, but it was also cheaper and much easier to work to the desired form than iron.

5 The Function of the Frames

In order to understand the structural function of the beams, two important elements must be taken into account. The first one is that, seen from the south, the foundations were at a height of about four metres from the ground. The second element is that the south part of the foundations were embedded in a portion of the peribolos wall that was essentially a retaining wall and had to withstand lateral forces (from the point of view of the Treasury) caused by the pressure of the soils. From a structural standpoint, therefore, the frames should not be considered so much as a reinforcement of the foundations (in the sense of layers of stone buried in the ground) as a reinforcement of a retaining wall where it was most vulnerable, i.e. most likely to open. This effect would have only been reinforced by the presence of a heavy structure (the south wall of the treasury) above this part of the wall.

A common solution in Greek architecture was the use of buttresses to help the retaining wall support the pressure exerted by the soils. Such buttresses were common from the end of the classical period. Examples include the fourth-century BCE retaining wall of the treasuries in Olympia, and later, in Messene, for the *skenotheke*.[34] In Delphi, buttresses are found in several monuments, but they are usually reversed buttresses located at the back of the walls, and served to secure the retaining walls into the soils.[35] Interestingly enough, in the case of the Theban Treasury, the builders also chose to resort to a hidden reinforcement system.

34 Egglezos 2019. Yoshitake 2021, 524–525, with references to other examples.

35 Bommelaer 1993, 44; Perrier 2021: 64–65.

Stability issues due to lateral thrusts are encountered in other parts of constructions. In buildings with a pitched roof, the main walls have to sustain the lateral thrust of the roof. In Greek temple architecture, two main types of roofing are attested that each deal with this issue in a different way. The first type is the post-and-lintel system. Here, a series of props counter the forces exerted by the ridge beam and the rafters, thus pulling the rafters inwards instead of outwards. The second type is the truss. Here, a tie beam connects the outer ends of the rafters to cancel the lateral thrust that they exert on the top of the walls.[36]

In the latter case, the tie beams usually do not exert any particular effect on the walls themselves, apart from a vertical load, as the truss is simply placed on top of the architraves without being connected to them. There are some cases in Greek architecture, however, where the tie beams were clamped to their support, thus effectively connecting parallel walls or colonnades to one another. Such was the case in the later third century BCE stoa of Attalos in Delphi, where the tie beams ensured the structural cohesion of the back wall and the front colonnade. Roux explained this unusual (though not unparalleled) system by the fact that the stoa was built on an artificial terrace and thus was exposed to landslide risks.[37] Roux mentioned two other examples of such a system in Delphi—at the Portico of the Aetolians and the East Building on the terrace of Attalos—and the 'Salle Hypostyle' in Delos, where the 'centrifugal' force exerted on the supports by the exceptionally large roof could explain the dowelling of beams on the supports of the 'lantern feature' in the centre of the building.

Comparable systems of tie beams were used in the Medieval period in order to prevent or contain lateral thrusts exerted by vaults and domes on their supports. These reinforcements, consisting of beams traditionally made of wood and, later, of iron, acted as girdles preventing the walls and pillars from being pushed outward. It seems that such systems could be found all over Europe during the Medieval period.[38] There are many examples, in Byzantine constructions, of horizontal wooden reinforcements of that sort. Choisy gave some examples of tie beams in vaults of the Byzantine period, whether in churches or in monumental cisterns.[39] These tie beams were often exposed and were either connected to wooden beams concealed in the masonry, or formed a

36 Hodge 1960, 35–44; Klein 1998, 335–339.

37 Roux 1987, 69–71.

38 Epaud 2008; Bella 2012. According to Viollet-le-Duc (1859, 397), the Merovingians and the Carolingians regularly used wooden beams concealed into the masonry.

39 Choisy 1883, 117–122.

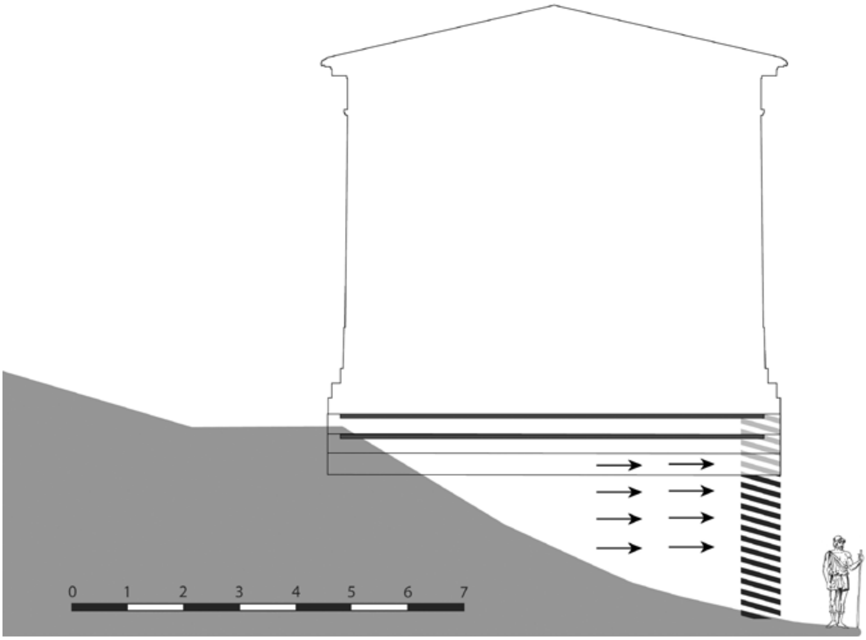

FIGURE 6.2 Schematic view, from the west, of the Treasury of the Thebans, and its location on the terrace, with the three courses of the foundations and the frames. After Didier Laroche (Jacquemin and Laroche 2012, 110 fig. 12)

network of exposed tie beams all acting together to contain lateral thrusts on the pillars. They were usually assembled with the saddle joint technique, as were the framings of the Theban Treasury.[40] In modern architectural restoration, tie beams are still used as ways of reinforcing vaulted structures.

These parallels further the analysis of the frames of the Treasury of the Thebans. As suggested by Michaud, differential settlements and earthquakes were the main threats to the integrity of the building. To these two factors one should add the lateral thrust induced by the soil mass on the south part of the foundations, which, in combination with the vertical load of the building itself, pushed the structure outward and downward. The frames tied the south part of the foundations to the northern part, which, as a consequence, was much less subjected to lateral thrusts and was thus much more stable. In this way, the lateral thrust exerted on the south part of the foundations remained contained, and the whole structure was better secured into the terrace itself (fig. 6.2). The system of grooves was thus fulfilling the role of buttresses, which

40 See Koumantos 2016; Ousterhout 2019, 397–398.

could not be used in this location, as a road ran down immediately below.[41] This solution was perhaps the best one that the builders of the Treasury could have come up with to deal with all of the potential risks all at once.

6 The Frames of the Theban Treasury and Greek Building Practice

While some have described the framing system found in the Theban Treasury as simply unique,[42] others have sought possible parallels, in Delphi and elsewhere. Partida found a similar system in an oikos near the theatre in Delphi.[43] She also compared the channels of the Treasury of the Thebans with the grooves cut across the blocks of a platform at the harbour of Anthedon on Euboea.[44] The channels in this platform do have a similar cross-section to the one of the Theban Treasury (about 11 cm wide and 8 cm deep). However, while there was a groove running parallel to the course and across the blocks, other grooves were cut transversely, and do not appear to have connected blocks together. Rather, they ran through the whole wall, from one end to the other. Rolfe, who first observed these structures thought that they could have been used to fasten blocks of the upper course or, more probably, that they were meant to allow seawater to run off.[45] However, the latter interpretation is hard to reconcile with the fact that some of these grooves did not lead outside of the structure, as was noted by Schläger, Blackman and Schäfer. They also ruled out the idea that these grooves were intended for ventilation because their cross-section was too small for such a function. Most importantly for the present argument, they discarded the possibility that the channels were filled with wooden inlays. According to them, a wooden framing would not have been sufficient to protect the structures against breakage. Furthermore, the shape of the channels, with varying width, was not suitable for wood. The decisive argument is that the wooden inlays would have been exposed to waves,

41 See Jacquemin and Laroche 2012, 111.

42 Michaud 1973, 24: 'une particularité intéressante (…) dont il n'existe, à notre connaissance, aucun équivalent dans l'architecture grecque'.

43 Partida 2000, 192–198; Partida 2017, 242–243. She does not discuss it in detail and does not specify which oikos. In the oikos *SD* 531, mortises were found, probably for the fixation of a wooden sheathing inside the building (Pouilloux 1960, 100; Bommelaer and Laroche 2015, 251). Their shape and purpose, therefore, differ from those of the channels of the Theban Treasury.

44 Partida 2000, 537.

45 Rolfe 1890, 102.

thus alternating between dry and wet states. Instead, Schläger, Blackman and Schäfer suggested that the channels were filled with mortar.[46]

Jacquemin and Laroche have pointed out that the rabbets documented by G. Roux on wall blocks of the stoa of Attalos in Delphi probably accommodated wooden beams, which served a similar function to the ones in the Theban Treasury—ensuring the cohesion of the blocks.[47] The interpretation and the comparison are persuasive, but some differences must be pointed out. First, the grooves of the stoa look quite different from the ones in the treasury. In the latter, the channels were completely concealed into the masonry, had the same depth on all sides and ran parallel to the foundation courses. In the case of the stoa of Attalos, some grooves ran parallel to the courses while others were cut transversally through the wall. The transversal grooves were shallower than the longitudinal ones, and the latter were not concealed, since they were cut along the outer edge of the blocks.[48] Furthermore, there is no indication that the frames of perpendicular walls were solidly attached to one another at the angles. While the frames must have had a reinforcement function, as perhaps attested by the deeper cuts in the middle course of the walls,[49] they served a different structural purpose. Indeed, in contrast with the Theban Treasury, which had to deal with important lateral thrusts combined with a dangerous position, the stoa only had to retain soils up to a certain height on its lateral walls; the back wall did not have a retaining function, which was fulfilled by an actual retaining wall.[50] A space was left between the two parallel walls, mainly to allow for the evacuation of water behind the stoa.

It is worth noting that most of the parallels mentioned so far are later than the Theban Treasury. They show that it was not as isolated a case as it appears at first sight, but they fail to explain the background and the origins of the framing used in the foundations of the building. While it can hardly be disputed that it constituted an innovation, it certainly did not appear out of the blue. In fact, it can be connected to a long tradition of craftsmanship and engineering.

Buildings made entirely or mostly of wood from the Greek world have left very few, if any direct traces, simply because very little organic material is preserved. As a result, and despite the input of textual evidence, the techniques of

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46 Schläger, Blackman, Schäfer 1968, 66–68.

47 Jacquemin and Laroche 1992, 244. Roux (1987, 52, 72–73) interpreted it as a unique and sophisticated system for fixing wooden panels to the walls.

48 See Roux 1987, pl. 39.

49 Roux 1987, 66.

50 On the west side, the 'Terrace of Neoptolemos' covered the wall up to about 4.3 metres. On the east side, the slope was rising to reach about 4 metres high at the level of the back wall of the stoa.

timber construction are much less well known than stone building techniques. Indirect evidence must be used instead. 'Petrified' forms of wooden architecture, although quite distant from their original source of inspiration, can be found in Greek temples and in the Lycian 'house-tombs'. Timber elements have also sometimes left negative traces in the stone or brick structures that supported them.

Timber reinforcements have been used since at least the fifth millennium BCE. They have been recorded in the Bronze Age in Anatolia, in Minoan Crete and in Mycenaean constructions.[51] They were still widely used in the Byzantine period and in Medieval Europe, and can still be found today in traditional domestic buildings.[52] The structural purposes of the uses of timber reinforcements, however, can vary considerably. I have already mentioned that they could be used against differential settlements or the opening of supports. They could also prevent the buckling and deformation of the walls, especially when made of mudbrick. In seismic regions and in military buildings, horizontal timbers could limit the spread of sapping effect. It also made portions of walls easier to repair. The third century BCE engineer Philo of Byzantium advised inserting oak beams in defensive walls and towers, so that they could be repaired more efficiently in case *lithoboloi* caused some damage.[53] Such wooden inserts are perhaps mentioned as 'ἐνδέσμοι' in a late fourth-century inscription pertaining to the restoration of the circuit wall of Athens.[54] The same word appears in an architectural context in an inscription concerning the foundations of the prostoon of the Eleusinian Telesterion (ca. 342 BCE),[55] but it is not certain what specific architectural element it referred to, or if this element was even made of wood.[56]

From this brief summary, it is clear that at the time of the construction of the Theban Treasury, there was a long tradition of the use of wood as a structural component of buildings. There is little direct evidence for the assemblage techniques of timber in construction at that time. However, preserved elements of furniture and especially shipwrecks show that a large array of techniques (including the tenon-and-mortise technique) were known in the

51 See, for Minoan domestic architecture, Pomadère and Hilbert 2019; for Minoan palatial architecture, Devolder 2019; and for Mycenaean walls, Rougier-Blanc 2019 (all in the same dossier of issue 110 of *Pallas*).

52 See Wilcox 1981, with many examples (mostly from the Medieval period).

53 *Compendium of Mechanics* 5, A 13.

54 *IG* II^2 463, l. 50: [ξυλίνου]ς ἐνδέσμου[ς].

55 *I. Eleusis* 151, l. 23–24, 27.

56 Davis 1930, 15, Jeppesen 1958, 139–143: stone elements; *contra* Hellmann 1992, 86 n. 16: 'chaînage en bois'.

fourth century BCE.[57] Furthermore, stone monuments displaying so-called petrified carpentry can give a glimpse at the techniques used for assembling timbers. Lycian funerary architecture shows, for instance, that the saddle joint was known and widely used in construction in Anatolia in the classical period and probably earlier.[58] This is further supported by channels documented on blocks found in Xanthos and in the neighbouring Letoon, in Lycia. The channels cross at the angles in a similar way to the channels of the Theban Treasury, and it has been suggested that they served to accommodate and support wooden structures, with saddle joints at the corners (which would explain that the cuttings extend further than their intersection).[59] Furthermore, literary sources, in particular Theophrastos' *Enquiry into Plants*, show that at the time of the construction of the Theban Treasury, the Greeks had acquired a thorough empirical knowledge of the properties of the various types of wood and their best use according to various factors such as durability, flexibility and strength.[60]

Structural issues, whether caused by sloping or uneven ground or by earthquakes, were well known to the Greek builders and architects by that time. Famous examples include the second Heraion of Samos, the foundations of which were laid on a one-meter layer of sand and a layer of limestone sherds.[61] The sixth-century Artemision at Ephesos was built on a marshy area; to prevent the effects of humidity and perhaps also to 'isolate' the foundations at the base, a layer of coal was laid under the foundations.[62] Later, at Bassai, the temple of Apollo was constructed in a way that increased its resilience to earthquakes: the peristyle and the sekos were structurally independent from one another, the foundations were not attached vertically to the upper platform, and the mortises for the rafters of the roof were cut in a dovetail shape, in order to allow the roof to twist slightly without breaking in case of an earthquake.[63] Finally, from the classical period onwards, clamps and dowels were more and more frequent, in order to ensure the unity of the structures. These clamps and dowels were usually embedded in lead, arguably allowing a certain flexibility of the buildings.

57 Barletta 2009.

58 On the Lycian tombs see Kjeldsen and Zahle 1975 (349, fig. 27: chronology table).

59 Cavalier 2002.

60 The fifth book of the *Enquiry into Plants* is dedicated to timber and its various uses. Theophrastos was, however, a pioneer, and sometimes inherited assumptions 'which interfere with his scientific approach' (Meiggs 1982, 17–19).

61 Kienast 1991.

62 Plin. *HN* 36.95; Diog. Laert. 2.103; Vetters 1988, 86.

63 Cooper 1996, 143–144.

In short, at the time when the Theban Treasury was built, its builders could draw upon long traditions of woodworking and of dealing with the threat of instability. Far from an improvised solution, therefore, the frames of the foundations must be considered a targeted response to specific structural problems, infused with a long accumulated technological know-how. That being said, it is difficult to trace a direct 'line of descent' for the use of this particular system. This difficulty might be due, as already discussed, to the scarcity of archaeological remains of structural timbers. It may also be due to the fact that the frames of the Theban Treasury were an actual novelty. The question then becomes: who or what could have possibly inspired such an innovative system?

As a working hypothesis, it can be argued that the frames of the Theban Treasury owe part of their design and conception to roof trusses and the work of carpenters. As already discussed, the frames of the foundations work, at least in part, as tie beams, in a way reminiscent of tie beams in a roof truss. While it was earlier thought that the truss was not discovered before the Hellenistic period, there is substantial evidence supporting the idea that it was already used in Sicily in the middle of the sixth century BCE.[64] This innovation was not widely adopted in the Greek Mainland in the classical period, and the Parthenon, for instance, does not show any evidence of a truss, despite having a wide cella span. Nonetheless, the basic principles presiding to the tie beams of a roof truss, and to tie beams in general, were known. As noted by Lamouille, triangulated structures were necessary for objects as varied as ships, cart wheels and cranes, and were thus known from early times.[65] Therefore, craftsmanship traditions possessed by carpenters and, more generally, woodworkers might have inspired the system found in the Theban Treasury. This is all the more probable if, as Feyel has shown, most craftsmen seem to have specialized in a type of material, rather than specific tasks. Particularly in the case of wood, epigraphic evidence from the Hellenistic period shows that a woodworker could produce a diverse range of wooden objects.[66] In view of the above, it is possible, if not likely that the device of the Theban Treasury was anchored in woodcarving traditions and, more specifically, in carpentry practices.

64 Hodge 1960, 35–44 (with earlier references); Klein 1998.
65 Lamouille 2019.
66 Feyel 2006, 382–384.

7 Conclusions

In this chapter I have discussed the rationale behind a quite unusual feature in the design of the Theban Treasury at Delphi. As I have argued, for economic and technical reasons, the channels are likely to have contained frames of wood rather than one of iron. As for the functions of these frames, comparative evidence suggests that they were meant to counter not only differential settlements and the effects of earthquakes, but also, at a more mundane level, the displacement of the stone courses under the combined action of lateral thrusts induced by the artificial terrace and of the vertical load of the building itself. Such a closer look at the stability issues that the device was designed to counter, combined with the acknowledgement that such issues existed and were dealt with in all periods of history, allows one to shift the point of view, from a focus on otherness to an emphasis on similarity and connectedness.

This analysis has shown how the concept of anchoring, and the underlying idea that all innovations are embedded into tradition to various extents, encourage us to seek the wider cultural and technological contexts of innovations that would otherwise seem, at first, completely isolated. Thus, although the precise genealogy of the frame of the Theban Treasury cannot be determined at this stage, one can reconstruct the context that made its invention possible. While the system was certainly designed to meet a particular set of locally specific constraints and therefore appears as rather unique and new, its shape, function and technical details largely fit into the craftsmanship and engineering practices of its time. As Sluiter and Versluys have stated, "imagining the possible takes its starting point from a particular sociohistorical context filled with peoples, things, and ideas".[67] Similarly, the builders of the Theban Treasury had access to a web of knowledge and practices from which they were able to draw their inspiration for its reinforcement device.

Abbreviations

CID II Bousquet 1989.

IG IV² Hiller von Gaertringen, F., *Inscriptiones Graecae, IV. Inscriptiones Argolidis. 2nd edn. Fasc. 1, Inscriptiones Epidauri*, Berlin, 1929.

67 Sluiter and Versluys 2020, 99.

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