Ancient Working Processes and Efforts Considering Large-Scale Constructions Made of Timber in Rome

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One of the biggest problems that appears during the interpretation and reconstruction of the traces of ancient architecture, lies in the circumstance that only a part of the material survives. Even if we talk about monumental architecture as we find it in Imperial Rome, we must not be mistaken about the mass of different types of stones. Just like in buildings of a smaller scale, timber played an essential role in the construction of these monuments.

In this paper, I will be trying to put my attention on three points. Firstly, I will give a short summary of ancient sources concerned about trees and the use of timber to give an idea what kind of knowledge and approach to that material was common during Roman times. The second point is a model, which I would like to propose to work with, including calculations of the types of wood used for certain constructions. After that, I will give two examples from the city of Rome itself. The reconstruction of architectonic elements might give us an idea what amount of timber was used in buildings, which are famous for their dimensions, but especially known for their remnants, which consist almost entirely stone.

Ancient literature on timber

Theophrastus was the first who wrote an enquiry to plants in his "Περὶ φυτῶν ἱστορία" in which he undertook a classification of different trees, plants and shrubs. The most important Roman texts are the books 12–17 of Pliny's "*naturalis historiae*" especially on trees.[1]

In book 16 we learn as an example that fir was considered useful for creating beams of a considerable scale, what we might take as an advice to use it for equal construction plans: "*materia vero praecipua est trabibus et plurimis vitae operibus*."[2]

About the use of timber for building purposes we are being informed by Vitruvius in his work "*de architectura*", in which he describes devices like hoists and cranes.[3] Likewise Pliny, he praises the characteristics of the fir: "*Itaque rigore naturali contenta non cito flectitur ab onere, sed directa permanet in contignatione*."[4] His contemporary Strabo explains the distribution of plants in the Mediterranean area in his "Γεωγραφικά."[5]

Types of trees used for building purposes

Most of the ordinary purposes would require local woods, which should be expected to have been available in the surroundings of Rome. Especially the oak is supposed to have

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played an important role in the building industry, concerning structures of moderate dimensions.[6]

If we try to create a model to reconstruct the ancient building economy of Rome, including aspects like transport, we need to know where the city obtained the material. In that sense, the oak would be representative for all types of local trees that Rome needed for common purposes of a moderate scale. Another kind of timber would have probably been available by the use of beech. The transport would not be far, considering that these kinds of trees should be available in the region of Latium.[7]

However, some architectonic elements could not have been made out of the mentioned timbers. In these cases, Romans had to find other solutions to satisfy the needs for structures like the big tie beams, which spanned over the central nave of the basilicas. The distance to cover reached spans of some 24 m, but regularly more than 12 m. The tree Romans seemed to be using for these purposes was the fir. It grew in the higher areas of the Apennine and delivered the kind of timber needed for big and strong beams.[8] The distance to Rome would differ from at least some 50 km to several hundreds of km.

Another tree with similar characteristics, but more resistant to fire is the larch, which can be found in the Alpine region. There is no evidence, that Romans have used the timber of that particular tree for building purposes before the time of Augustus. And still afterwards fir seemed to be the preferred choice. One reason for that might be the distance, which made the transport to Rome quite difficult.[9] In his work about architecture, Vitruvius laments that very fact: "*Cuius materies si esset facultas adportationibus ad urbem, maximae haberentur in aedificiis utilitates,* […]."[10]

Even the nearest connections to the Alpine region would have required a transport of the material to Rome over the distance of at least 500 km, but in many cases more.

The last aspect leads us to adopt the idea that more exotic timbers like Lebanon's cedar would only be subject of transport to Rome in very special circumstances. In my following thoughts, this circumstance shall be rejected, even in the case of the large tie beams crossing the span of the central nave of Trajan's great basilica erected on his forum.

A calculation of the quantity of timbers used in the roof truss of the Basilica Ulpia

The following bit is an attempt to estimate the quantity of material that was used in the roof truss of the Basilica Ulpia, the biggest basilica ever built. Its central nave had a span of ca. 25 m (or 85 Roman feet).[11] A first step is to describe the single elements of the construction and establish the number needed for each of it.

The biggest problem concerning the reconstruction of an ancient roof truss is an obvious one. No example has survived to our day. Therefore, we need to look for structures that we can at least compare roughly to Trajan's construction. Searching for similar typologies, the early Christian basilicas in Rome seem to deliver the examples

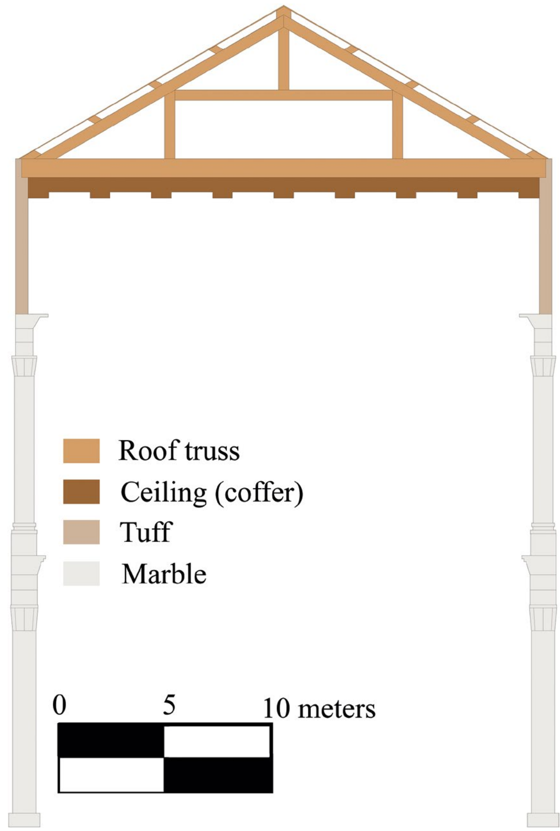

Fig. 1: Reconstructed section of the Basilica Ulpia.

most appropriate. Rodolfo Lanciani was still able to describe the measurements of a tie beam from the original roof truss of Saint Peter's. I shall be content to deal with the value given by him for its thickness, which is 91 cm.[12] We shall also follow the assumption that the beams of the roof truss, like in the Christian basilicas, would have been made out of a single piece.[13] The measurements for the remaining elements of the roof shall be taken from an example of Augustan architecture.

In the case of the forum of Augustus the big surrounding wall has survived in great parts until this day. What makes it a particularly fortunate circumstance, is the fact that many of the structures that were built into the wall itself have left traces of the elements where they connected. The missing blocks, which were refilled in later times in the area of the porticoes, are being interpreted as the imprint of the tie beams and rafters of the roof. Since this hole formed a square of four Roman feet (1.18 m; comprising the end of the tie-beams and rafters)[14], we shall be confident to apply similar measurements for the beams that provided the rafters and the remaining upper structure of the roof truss. Likewise, the imprints of the purlins have survived with a size of 60 cm in section.[15]

A roof truss as shown in the established reconstructions[16] of the Basilica Ulpia should be composed of the single elements as follows* (fig. 1):

Type of structure	Length in m	Width in m	Height in m	Volume in m³
Tie-beams	25.25	0.91	0.91	20.91
Rafters	13.88	0.60	0.60	5.00
Vertical beams (central)	2.83	0.50	0.50	0.71
Vertical beams (to each site of the centre)	3.32	0.50	0.50	0.83
Horizontal beams	10.47	0.50	0.50	2.62
Rows of Purlins	90.00	0.40	0.40	14.4
Roof covering for each half of the nave	90.00	14.75	0.05	132.8

Table 1: Construction elements of a roof truss (Basilica Ulpia).

- 18 Tie-beams with a volume of 20.9 m^3 each, altogether **376.3 m^3**
- 36 rafters with a volume of 5 m^3 each, altogether **179.9 m^3**
- 18 vertical beams in the center with a volume of 0.7 m^3 each, altogether **12.7 m^3**
- 36 vertical beams to each side of the center with a volume of 0.8 m^3 each, altogether **29.9 m^3**
- 18 horizontal beams with a volume of 2.6 m^3 each, altogether **47.1 m^3**
- 10 rows of purlins along the length of the nave with a volume of 14.4 each, altogether **144 m^3**
- Volume of the roof covering: **132.8 m^3**
- Adding all elements together the quantity of timber would add up to a number of **922.7 m^3**

*The assumption being that a tie beam lies above each of the columns around the central nave, the numbers will already have been rounded.

Proposal for a model to work with

If we want to determine the kind of timbers possibly used in a construction like the Basilica Ulpia's roof, there are three groups of the architectonic elements mentioned just before.

The simplest element is the roof covering consisting of wooden planks, which could have been obtained by the use of oak or other local trees.

A second group would comprise all other beams with the exception of the big tie beams spanning the nave. Although in comparable constructions, but on a smaller scale, these elements probably could have been made out of local woods, too, in the case of a large-scale building like the one in consideration, we should assume the need of stronger material.

Following our thoughts in the previous chapter about the types of timber in use for building, the fir seems to be the one to look for. In many cases, roof trusses of porticoes or basilicas of "moderate" scale should have also been made by fir, including the big tie-beams, but in our case, it is to assume that there was still another type of timber used.

The large tie beams, which had to span a distance of ca. 25 m (and therefore be even longer than that), could have been probably made out of larch. But in the case of an Imperial building in the very sense, we might be attracted to the idea that the famous cedars of today's Lebanon would have been imported to achieve the completion of the Basilica.[17] Nevertheless, the use of cedar as a construction material has been classified as unlikely.[18]

Following our model, the distribution of the different types of timber shows up as follows:

- oak (or other local trees) would add up to **132.8 m³**
- fir would take up the largest part of the total amount with **414.5 m³**
- cedar or larch would add up to **376.3 m³**

The numbers seem to suggest that the construction of the roof trusses of the ancient big porticos and basilicas could have been only in a small part operated by local materials.

An estimation for two hypothetical structures made of timber in the Colosseum

Although nothing of the upper parts inside the Colosseum, with the exception of the perimeter wall, survives, it has been generally agreed that the upper standings in the amphitheater would have been made out of wood.[19] Two parts shall be examined in this place (fig. 2).

Firstly, the stairs of the so-called "*maenianum summum in ligneis*" and secondly, its roof following the reconstruction shown by Rossella Rea in the 90's.[20]

The quantity of timber will be calculated for one of the building's sections and then be multiplied by 80. With a single section 6.55 m wide[21] and covering the span equivalent to the outer gallery of the ground floor (5 m)[22], assuming a thickness of ca. 30 cm (one Roman feet), the number can be established at 9.825 m^3. For the quantity altogether, we have to consider all 80 sections arriving at some 786 m^3 for the ceiling of the upper portico in the Colosseum.

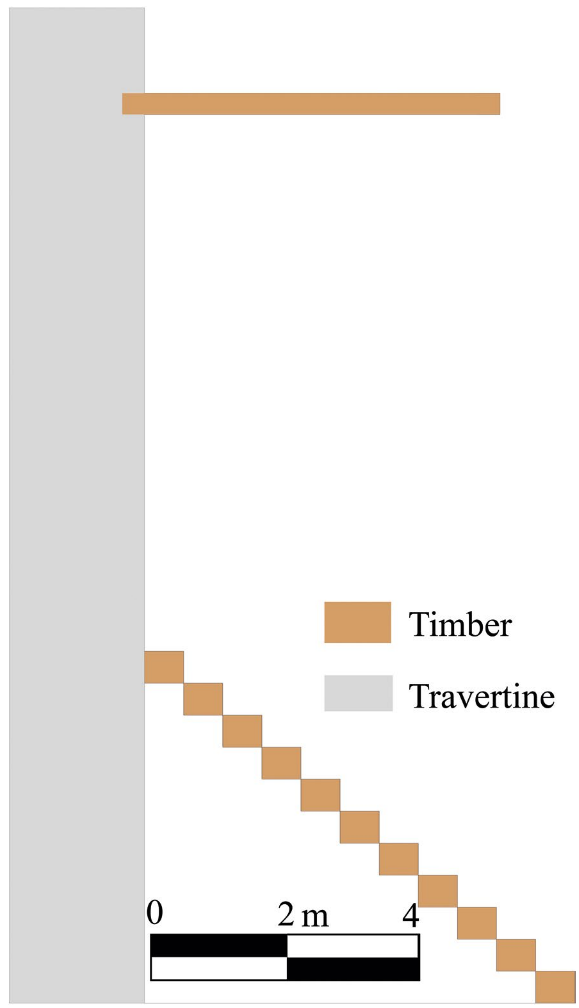

Fig. 2: Scheme of a reconstructed section through the highest ranks of the Colosseum

The second part to be estimated is the amount of timber for the steps of the grandstand. Its understructure will not be considered, as this part would be subject to more difficulties concerning its reconstruction. Van Gerkan proposed a height for each of the eleven steps of 55 cm.[23]

The width of the steps might be taken from a similar structure, which can be found in the steps of the cavea of Domitian's stadium in Rome. Scattered remains of its upper cavea have been found, allowing for a tread of 45 cm.[24] The manner to calculate the amount of timber is to establish the quantity for one step in one section of the building, then multiply it by eleven for all steps in one section. Finally, this number has to be multiplied further by 80 to get the amount for the whole building. Following these steps, we reach 1.62 m^3 for one step in a section, 17.83 m^3 for the eleven steps in one section and about 1,426.59 m^3 for the grandstand's steps all around the building.

Conclusion

In my paper, I have tried to make some considerations about the use of timber in grand-scale constructions in ancient Rome. Even though the exact numbers will always be an object of speculation, it became quite clear that in Rome's big buildings, the use of timber made an important part of the quantity of material that had to be supplied to the city's construction areas. The three examples shown are just a little aspect of all the timber that was used during constructions. Too often, we forget about that fact due to the bad conditions of preservation.

I also tried an approach to the question, what kind of trees would have been used by the Romans for a certain kind of architectonic structure. An intensification of matters like that in the future would be very welcome to our whole field of study. It certainly is helpful to make these considerations and develop them further using the ancient sources as a support, but without being totally dependent on them at the same time.

Notes

[1] Meiggs 1982, 17. 22.

[2] Plin. nat. 16. 18, 42. "But it supplies excellent timber for beams and a great many of the appliances of life".

[3] Meiggs 1982, 30.

[4] Vitr. 2. 9, 6. "It is held together by a natural stiffness, and is not quickly bent by a load, but remains straight in the flooring".

[5] Meiggs 1982, 30–32.

[6] Meiggs 1982, 221.

[7] Meiggs 1982, 219.

[8] Meiggs 1982, 226–227.

[9] Meiggs 1982, 248.

[10] Vitr. 2. 9, 16. "And if there were a provision for bringing this timber to Rome, there would be great advantages in building; [...]".

[11] Ulrich 2007, 149.

[12] Packer 1997, 239 note 48.

[13] Meiggs 1982, 241–242.

[14] Bauer 1985, 233.

[15] Ganzert – Kockel 1988, 186.

[16] Meneghini 2009, 140 fig. 176.

[17] Packer 1997, 241.

[18] Eissing 2011, 15.

[19] Colagrossi 1913, 69.

[20] Rea 1996, 71 fig. 60.

[21] Cozzo 1928, 210.
[22] Beste 2007, 86 fig. 4. 1.
[23] van Gerkan 1925, 39.
[24] Colini – Virgili 1943, 104.

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