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## FROM THE TOWER TO THE BASTION. CHANGES IN FORTRESS DESIGN TO ACCOMMODATE GUNPOWDER ARTILLERY (14<sup>TH</sup> TO 16<sup>TH</sup> CENTURIES)

**Abstract:** The authors set out the key turning points in the evolution of defensive architecture in response to the appearance of firearms in the 1<sup>st</sup> quarter of the 14<sup>th</sup> century in Europe, for both attack and defence. Between the first adaptations to defences during the middle of the 14<sup>th</sup> century to the emergence of geometric whole defensive systems based on low-lying bastions and interconnected outworks in the 16<sup>th</sup> century, there was a long period of evolution, experimentation and development, responding to continuous improvement in the range and destructive power of gunpowder artillery. New designs of castles, fortresses and town walls focussed on the need to shield high medieval walls and towers against the power of the gun, but also on how to mount guns on defences and integrate loop holes to keep an attacker as far away as possible. Ideas diffused rapidly across Europe and the Muslim world. Factors such as the builder's wealth and the purpose of the fortress also determined what was constructed.

**Keywords:** Europe, firearms, defensive architecture, castle, fortress, loop hole

**Received:** 31.03.2020 **Revised:** 24.04.2020 **Accepted:** 27.05.2020

**Citation:** Krauskopf C., Purton P. 2020. *From Tower to the Bastion. Changes in Fortress Design to Accommodate Gunpowder Artillery (14<sup>th</sup> to 16<sup>th</sup> Centuries)*. "Fasciculi Archaeologiae Historicae" 33, 89-101, DOI 10.23858/FAH33.2020.006


It took up to two hundred years to progress from the first confirmed appearance of gunpowder weapons in Europe and the Middle East to the first new fortifications wholly designed according to geometric principles and based on the use of low-lying, interlocking bastions and outworks to defend against and to mount artillery.


The authors are researching this long process in detail, to explore how and when changes were made in fortress design, but also what inspired such developments and how effective they were. One challenge is that there are thousands of examples across the Christian and Muslim worlds; the second is that there is uncertainty about dating many of them. This paper suggests a few critical turning points (Fig.1).

One thing is clear at the start. Wherever a change was made, it did not remain private for long. The medieval

ruling class was international and so were medieval engineers.<sup>1</sup> Technological change diffused rapidly. It is rare that we can prove which country or which ruler was the first to make something wholly new.

There is, however, good evidence to suggest that the first changes to fortifications to accommodate the new weapon were made in England, during the Hundred Years War with France. This fits well with the evidence that gunpowder was first used in war in Europe in the early 14<sup>th</sup> century. The English used guns at the battle of Crécy in 1346 and at the siege of Calais immediately after, although with little effect. The first datable evidence of fortifications being adapted so that the defenders could use these small and inaccurate weapons was at the abbey of Quarr on the Isle of Wight, which was subject to seaborne attacks by the French, when a wall was built with two square holes cut through it (Fig. 2), in 1365.<sup>2</sup> The gun must have sat on a timber

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<sup>1</sup> See Purton 2018, passim.

<sup>2</sup> Renn 1968, 301-302.



Fig. 1. Map of locations of the sites mentioned in the text. Map C. Krauskopf, BLDAM: Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum.

restle. Possibly even earlier, 1347, although this date is not definite, were the holes built into the wall of the rich city of Norwich<sup>3</sup> which are also small, and crude (Fig. 3).

Soon after, fortresses are found where holes cut into walls for the use of guns became part of the design itself. In England and France there are many examples from castles and town defences built in the 1370s and 1380s. These were usually circular loops for the gun at the end of vertical sighting slits, often using a timber base on a stone sill for resting the gun. However, the design of the wall or tower was not changed from traditional forms. At this time, it appears, no one was concerned that the guns of the attacker could damage the masonry, it was only about using the gun to defend from the inside. Figure 4 is a small baron's castle at Cooling in Kent built in 1381. It may be a status symbol although the English peasants' revolt and similar loops at other contemporary fortifications in this region (south east England), such as the major works on the city wall of Canterbury, suggest another context. The royal chief engineer, Henry Yevele, was involved in all these works.<sup>4</sup>

The evidence for adapting defensive architecture to the new weapons is quite rare – despite of the fact

that firearms were quite common in the 2<sup>nd</sup> half of the 14<sup>th</sup> century all over Europe. But firearms still had little effect, as we can see from many sources. In a document from 1395 concerning the liberation of the King of Sweden and his son from captivity in Denmark, northern German towns had to deliver firearms – but only four cannons and six guns together with the amount of gun powder required for the weapons. But they had to provide 300 marksmen with good crossbows! That may shed a light on the significance of firearms until the end of the 14<sup>th</sup> century.<sup>5</sup>

The next turning point was to move from inserting new gun ports in existing defences to specifically designing gun towers, sometimes newly built, sometimes adapted, which become larger and stronger through the 15<sup>th</sup> century. One of the first may be also from England, the 'God's House Tower' built at Southampton not later than 1417 (Fig. 5), again in response to the threat of seaborne attack. This projecting tower allowed guns at two levels to fire in all directions from secure positions, sitting on the ground or the roof, behind thick walls.<sup>6</sup>

The gun tower rarely stood alone. Alongside the tower, which might be round, rectangular or square, many rulers across Europe turned to the erection of additional external defences, sometimes of earth, sometimes masonry, or both, to shield the old towers and

<sup>3</sup> Ayers 1994, 65.

<sup>4</sup> Harvey 1944, 36, 38-39; Renn 1982, 117-118; Tatton-Brown 1985.

<sup>5</sup> MUB 1907, 535.

<sup>6</sup> O'Neil 1960, 11; Saunders 2000, 53-58.



Fig. 2. Quarr Abbey, Isle of Wight. Wall and gun loops, 1365. Photo P. Purton.



Fig. 3. Norwich (Norfolk): loops in St. Stephen's Gate, possibly 1347. Photo P. Purton.

walls from the increasing effectiveness of guns as a result of technological progress in metallurgy and improvements in the manufacture of gunpowder itself, which meant that by around 1400 for the first time larger guns now posed a threat to stone defences and there are increasing references as the 14<sup>th</sup> century progressed to bombards demolishing stretches of wall with

shot weighing 50 to 100 kg. Examples of shield walls are found in the mid-14th century in Germany, a region where the manufacture of guns and gunpowder was becoming a major industry.<sup>7</sup>

<sup>7</sup> The German term *Schildmauer* describes parts of the curtain wall which are taller and thicker than the rest of the curtain wall.



Fig. 4. Cooling castle (Kent), built 1381 – gun loops.  
Photo P. Purton.

On the continent as in Britain, high slim towers, still in older defensive traditions, with loops for handguns were erected. According to the account books the castle in Bytów (former Bütow) in the territory of the Teutonic Order in Prussia was built between 1399 and 1406<sup>8</sup> (Fig. 6). The account books allow the reconstruction of the building process to be followed in detail. The measurements of the completed masonry served as basis for payments to the masons and other crafts.<sup>9</sup> Bytów seems to be a very early example and unique in the territory of the Teutonic Order during that period. Christof Hermann is of the opinion that master John, who constructed the extension of the Grand Masters palace of the Malbork (former Marienburg) beginning around 1380, also worked at Bytów.<sup>10</sup> The castle was a completely new construction with a unique plan compared to the other castles of the Teutonic Order in that region. It comes back to a well-trying composition, common in west Europe and Bohemia since the 12<sup>th</sup> century, the quadrangular castle with corner towers.<sup>11</sup> In the lands of the

Teutonic Order there exists only one other example, the castle of Świecie (former Schwetz), which dates between 1335 and 1350.<sup>12</sup> The innovation of Bytów is the three round corner towers, equipped for the use of handguns with hooks. Today partially heavily restored, originally the lower floors were open to the castle's yard. Different sizes and shapes of gun loops indicate that the builder experimented with the new forms of defensive architecture<sup>13</sup> – as is to be seen in other buildings of the early and middle 15<sup>th</sup> century.<sup>14</sup> The towers differ very much compared with roundels and battery towers of the 15<sup>th</sup> century, they are very slim and still in a “medieval tradition”. Another example of these early gun towers can be seen in the corner tower of the castle of Greiffenberg in Brandenburg. It is equipped with narrow gun loops in the top floor. The loops could only be used with guns with quite long barrels, hooked on a wooden bar, built in the rear part of the opening (Fig. 7). It is not possible to date the tower more precisely. It belongs according to present knowledge to the third building phase, dating to the 2<sup>nd</sup> half of the 14<sup>th</sup> or 1<sup>st</sup> half of the 15<sup>th</sup> century.<sup>15</sup> Assuming that the loops belong originally to the tower, it seems impossible that the building existed before 1400.<sup>16</sup>

Gun towers began to spread quickly after the earliest examples in Britain. The Hussite wars in Bohemia led to significant developments as many fortifications were modernised. For a long time, Tábor was hailed as an early example of gun towers built from the 1420s, but this dating, especially for the Kotnov tower, has now been challenged.<sup>17</sup> The town was fortified with an outer ward<sup>18</sup> with polygonal gun towers. One of the oldest gun towers in Bohemia existed in Worlik (Orlík nad Vltavou).<sup>19</sup>

The impact of the Hussite wars led to the construction of gun towers in neighbouring regions such as Franconia. Several examples have been discovered by Joachim Zeune, such as the towers at Altenstein with inversely arranged T-shaped gun loops or Lichtenstein, both dated to the time around 1430.<sup>20</sup>

<sup>12</sup> Herrmann 2011, 162.

<sup>13</sup> Herrmann 2011, 162.

<sup>14</sup> See below, especially on the Castle Eisenhardt in Bad Belzig.

<sup>15</sup> Chantre and Rathgeber 2008, 26, Figs. 27 and 30.

<sup>16</sup> During the analysis by Christiane Chantre and Julia Rathgeber it was not possible to examine the corner tower in detail.

<sup>17</sup> Varhaník 1997; Durdík 2000; Durdík 2007, 38-39.

<sup>18</sup> Outer ward is here used for the German term *Zwinger*, meaning the space in front of the main curtain wall, which is sheltered by a second, in most cases lower wall, often equipped with flanking towers. The terms lower or outer bailey are also used as translation for *Zwinger*, but describe a different phenomenon. Even outer ward may mean more than what is described by the term *Zwinger*. In the area of the Teutonic Order, the term *Parcham* is used.

<sup>19</sup> Varhaník 1998, 31, Figs. 8-12.

<sup>20</sup> Geibig and Zeune 2003, 184-186; Zeune 2011, 76-77.

Shield walls cover buildings and parts of castles against bombardment with trebuchets, and, from the 15<sup>th</sup> century, cannons.

<sup>8</sup> Herrmann 2011, 160-162.

<sup>9</sup> For details see especially Lemcke 1911, 153-158.

<sup>10</sup> Herrmann 2019, 398, 411.

<sup>11</sup> Durdík 1994; Schicht 2003.

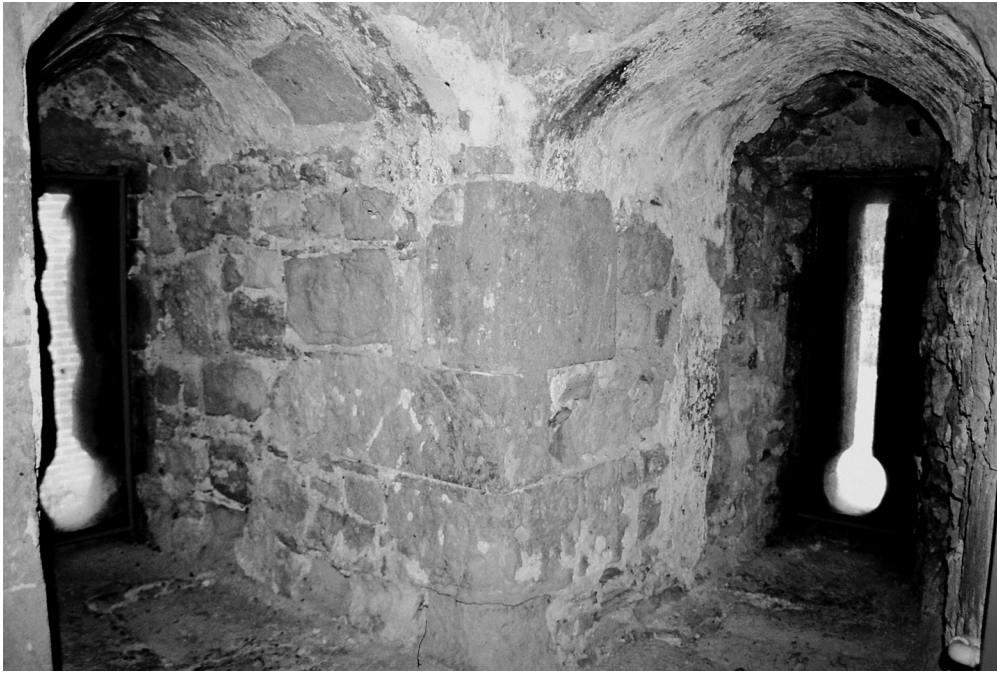


Fig. 5. Southampton (Hampshire), city walls. The 'God's House Tower', built by 1417. Photo P. Purton.



Fig. 6. Bytów (Poland), front of the castle with two guntowers. Photo C. Herrmann.

Lichtenstein is especially interesting. Between 1417 and 1436 1000 gulden were invested in two gatehouses and a gun tower in the so called Nordburg and an outer ward in the Südburg. The loops in the gun tower were first interpreted as arrow loops constructed for the use of longbows as they are 3 m long and 20 cm wide. But thorough investigation revealed that the loops were constructed for two marksmen on two levels (Fig. 8). Traces of horizontal timber beams on the two levels and at the shorter gun loops in the upper

storey prove the use of guns equipped with hooks. In a document from 1430, issued by the bishop Johann of Würzburg concerning the building activities in his castle Lichtenstein, he mentions the reasons for the works: "[...] the infidel damned heretics from Bohemia [...] therefore it is very important to fortify towns and castles in this country."<sup>21</sup>

<sup>21</sup> Zeune 2011, 76. The source is partially edited by Bodo Ebhardt (1901, 173).



Fig. 7. Greiffenberg (Brandenburg), gun loop on the corner tower. Photo C. Krauskopf, BLDAM.

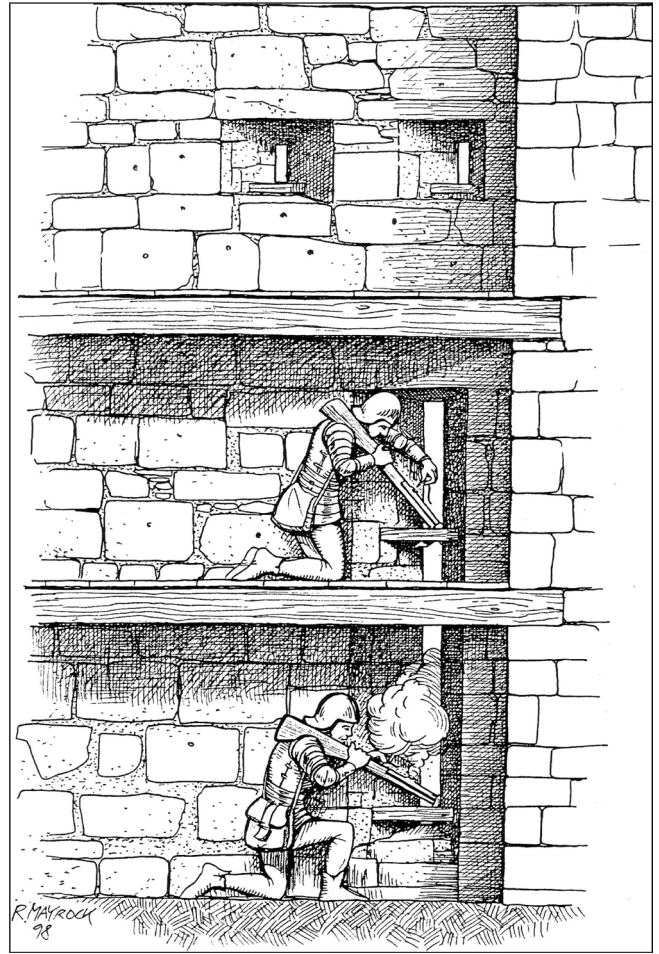


Fig. 8. Lichtenstein (Franconia), reconstruction of the interior gun tower. Drawn R. Mayrock, Büro für Burgenforschung J. Zeune.

One major means of defence very quickly became the attempt to keep the attacker away from the inner defences. Two older concepts, the outer ward, and the shield wall, were adapted to the new defence systems.

Shield walls should prevent attackers from causing damage to the castle buildings with missiles thrown into the castle. A very impressive example is preserved in the Farnsburg near Basel.<sup>22</sup> The wall dating to the mid-14<sup>th</sup> century is 3 m thick and about 8 m high. Often shield walls were not that thick, they impressed visually but might not have enough strength to withstand attacks with trebuchets. The impact of the missiles of bombards and cannons in the 2<sup>nd</sup> half of the 15<sup>th</sup> century was much stronger than that of trebuchets. Nevertheless, even old shield walls could withstand bombardments with cannons – the already mentioned wall of the Farnsburg was bombarded for three weeks in 1444 without success.<sup>23</sup> Newly-erected shield walls were often equipped with gun loops and

combined with gun towers, as in the Trendelburg in Hesse<sup>24</sup> (Fig. 9). Not before the late 15<sup>th</sup> century the dimensions of shield walls changed at the time of the impact of heavy firearms, as in Neu-Scharfeneck in Germany. The shield wall of Helfstýn (Helfenstein) in Moravia shows two segmented arched projections.<sup>25</sup> In many cases shield walls were combined with gun towers as in the Hohkönigsburg in Alsace<sup>26</sup> or Worlik (Orlík nad Vltavou) and maybe also Výrov in Bohemia.<sup>27</sup>

The older examples of outer wards from the late 13<sup>th</sup> and the 14<sup>th</sup> centuries were often not very thick walls with flanking towers, encircling the inner castle at a short distance.<sup>28</sup> A well-known example is the outer ward of the castle of Prague. The construction

<sup>24</sup> Friedhoff 2011, 69-70; Brohl 2013, 189-194; Strickhausen and Strickhausen 2015.

<sup>25</sup> Durdík and Bolina 2001, 193.

<sup>26</sup> Uhl and Zeune 1999, 234.

<sup>27</sup> Orlík: Varhaník 1998, 31, Fig. 15; Výrov: Durdík 2005, 164.

<sup>28</sup> To the outer ward in general and to its effectiveness see Gutbier 1976; Müller and Schmitt 2007; Meyer 2009.

<sup>22</sup> To the Farnsburg see Meyer 1981, 94-97; Schmaedecke 2005.

<sup>23</sup> Meyer 2009, 241 and footnote 25.

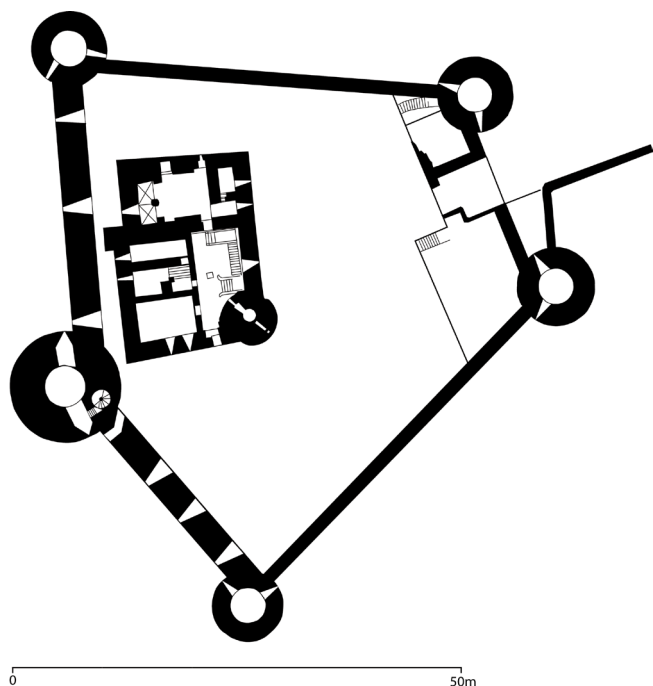


Fig. 9. Trendelburg (Hesse). Redrawing after *Atlas* 1967, 33B, Photo C. Krauskopf, BLDAM.

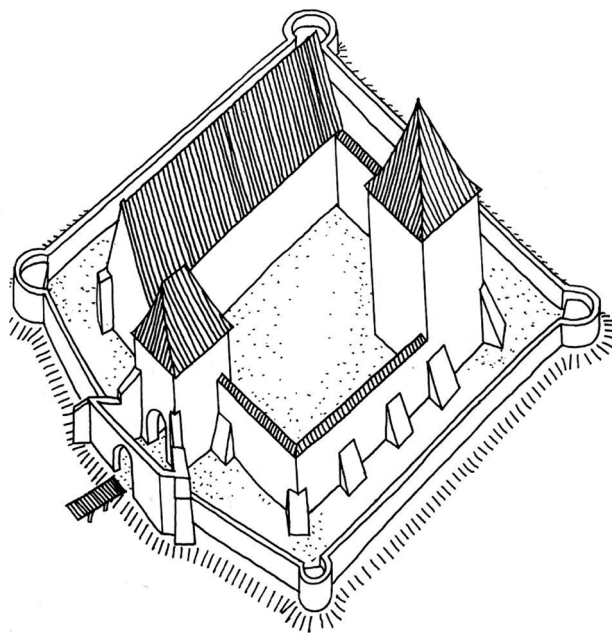


Fig. 11. Wenczja (Poland). After Salm 2011, Fig. 11.

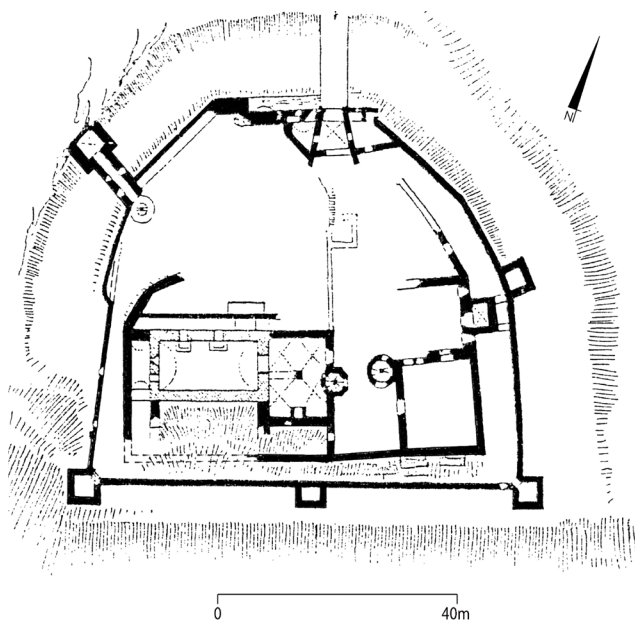


Fig. 10. Kollenberg (Franconia). After Feulner 1913, Fig. 35.

began in 1370, when Emperor Charles IV decided to strengthen the southern defences of the castle.<sup>29</sup> In the 15<sup>th</sup> century new outer defences with flanking, powerful, gun towers were erected by the engineer Benedikt Ried on the south and north sides. Tábor has already been mentioned, but there are

various other examples, such as Kollenberg in Franconia with a polygonal outer ward with rectangular flanking towers (Fig. 10). The castle has a very early example of a caponier, built in connection with the outer ward also around 1430.<sup>30</sup>

The new types of outer wards became a critical part of defensive architecture. Newly-built castles in the late 14<sup>th</sup> century often still lack this important part. Landgrave Hermann II of Hesse built Hermannstein near the town of Wetzlar from 1376 against Count Johann IV of Solms-Burgsolms who had taken the town in that year. The castle – specially erected in a conflict – consisted of a big donjon with nearly no defensive features.<sup>31</sup> A comparable concept was followed while refortifying the Weidelsburg. Landgrave Hermann II and the count of Waldeck agreed to rebuild the older ruined castle and to equip it with troops and weapons. But they built only a big donjon – the outer ward with inverted keyhole gun loops dates to the 1420s or '30s.<sup>32</sup>

During the first decades of the 15<sup>th</sup> century the construction of outer wards became common. In many parts of central Europe, they were erected around older castles. There are countless examples in central Europe, one of the most famous being in Malbork,<sup>33</sup> others in

<sup>29</sup> Chotěbor 2007, 161.

<sup>30</sup> Feulner 1913, 59-69; Zeune 2011, 81-82.

<sup>31</sup> Gutbier 1973, 158-163; Friedhoff 2011, 63-64.

<sup>32</sup> Gutbier 1999, 155; Friedhoff 2011, 64; Knöppel 2017.

<sup>33</sup> Pospieszny 2007 with further mentions of older literature.

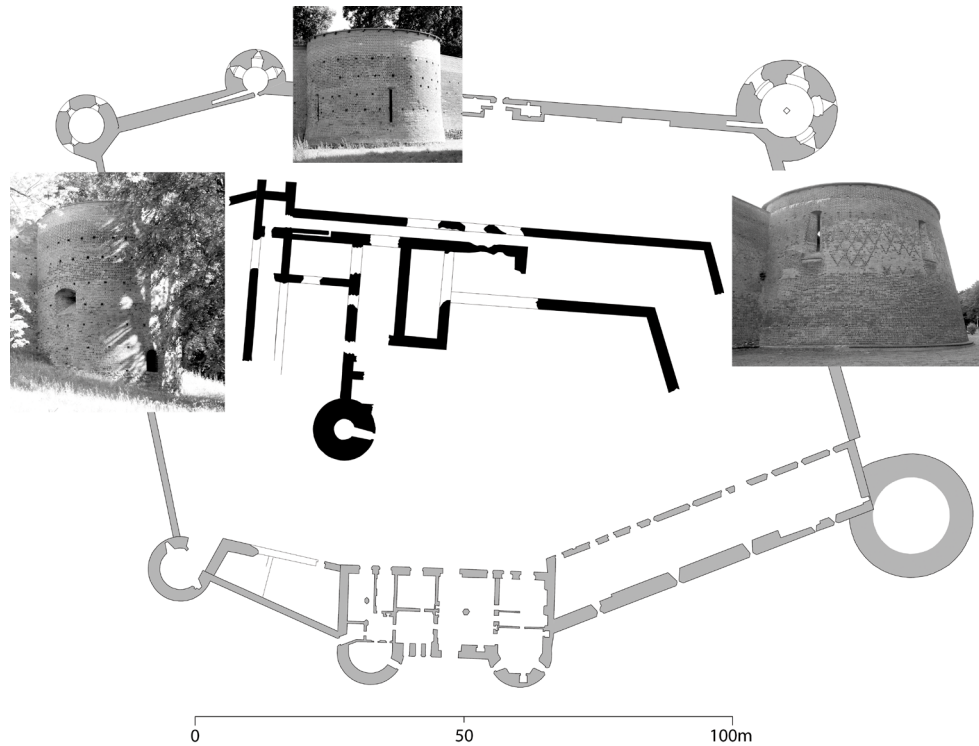


Fig. 12. Castle Eisenhardt, Bad Belzig (Brandenburg). Redrawing of a plan of the Royal Government Potsdam by building officer Köhler, 1890 and photos of the three northern towers. Photo C. Krauskopf, BLDAM.



Fig. 13. Zossen (Brandenburg), battery tower. Photo D. Möller, BLDAM.



Fig. 14. Gerswalde (Brandenburg), guntower. Photo C. Krauskopf, BLDAM.

Wenecja in central Poland (Fig. 11)<sup>34</sup> or Schweinsberg in Germany, the last example connected to the master builder Hans Jakob von Ettligen.<sup>35</sup>

From the mid-15<sup>th</sup> century a similar defensive concept was established. Very strong walls were erected to fortify new places or encircle older castles. They were equipped with big gun towers, evoking the flanking or corner towers attached to the outer ward – but they were much stronger buildings with gun loops and

cannon ports. The first fortresses as complete defensive systems were erected and that happened all over Europe during a very short time.

Honberg near Tuttlingen, built from about 1460 on, is regarded as the first fortress in Württemberg.<sup>36</sup> Also since the 1460s the electoral princes of Saxony began to refortify the castle mount of Belzig, situated on the northern border against the principality of Brandenburg.<sup>37</sup>

<sup>34</sup> Salm 2011, 151.

<sup>35</sup> Gutbier 1973, 134-157; Ottersbach 2015, 197, Fig. 17.

<sup>36</sup> Ottersbach et al. 2014, 135ff.

<sup>37</sup> Bergmann 2005; Langer 2007; Langer 2011; Krauskopf 2011, 54-55; Gebuhr 2018.





Fig. 15. Auxonne (Côte d'Or). Embrasure in the foot of the gun tower, covering ditch and entrance. Photo P. Purton.



Fig. 17. Dubrovnik (Croatia). Minčeta tower and surrounding outer wall and curtain rebuilt by Michelozzo from 1461. Photo P. Purton.



Fig. 16. Ostia, near Rome. Fortress, built mid-1480s. Photo P. Purton.

Evidently the architects experimented with different concepts for the five big gun towers. They created different gun loops, from long slits in a conical tower to round or mouth shaped loops in cylindrical towers (Fig. 12). The electoral princes of Brandenburg began to build their first fortress later. At the end of the 15<sup>th</sup> century they erected – comparable with Belzig – a fortification with horseshoe-shaped gun towers around the older castle of Zossen on the southern border of their territory. Only one of the gun towers survives today (Fig. 13).<sup>38</sup>

Of course, not every nobleman could afford to build fortresses like the Counts of Württemberg or the electoral princes of Saxony and Brandenburg. So, many castles were strengthened only with single gun towers

as in the examples of Greiffenberg and Gerswalde in Brandenburg<sup>39</sup> (Fig. 14).

But with the growing effectiveness of cannons, the question of how to keep attackers further away, while also being able to flank the curtains effectively, became a dominant concern for designers of fortresses. The answer, we now know, was the low-lying fortress with interconnecting bastions for mounting guns combined with large scale linked outworks but hindsight is the enemy of good history and this solution was not obvious in the 15<sup>th</sup> century. Instead we find large numbers of new fortresses that tried to resolve the problems with different solutions. The decades from 1450 to 1510 were a time of transition and experimentation. Many books were written during this time advancing solutions to the questions posed by modern artillery but only a few were acted on by rulers, maybe they preferred what they knew from practice or maybe they could not afford to build the designs of Giotto, Taccola, Alberti, Filarete, Giorgio Martini or Leonardo da Vinci.<sup>40</sup>

The gun tower remained central in practice. Louis XI of France conquered Burgundy in 1477 and built his 'three sisters', enormous new fortresses to secure the province. One remains, at Auxonne (Fig. 15), where the plan is a pentagon and there are two gun towers with walls five metres thick and ravelins in front of each gate.<sup>41</sup> Not a new design, but the strongest of the current, perhaps?

Much that was new was built in Italy and many survive today. Here there is space only to mention Ostia

<sup>39</sup> Greiffenberg: Chantre and Rathgeber 2008; Gerswalde: Krauskopf 2011, 54.

<sup>40</sup> Purton 2010, 358-362.

<sup>41</sup> Mesqui 1997, 37-40.

<sup>38</sup> Krauskopf 2011, 56; Cante 2015.



Fig. 18. Salses (Pyrénées orientales), 1497: ditch, caponier and corner towers with talus added after failed French siege 1503. Photo P. Purton.



Fig. 19. Rhodes. Medieval walls, ditch and tenaille from St. Athanasios tower. Photo P. Purton.

(Fig. 16), near Rome, which dates to the mid-1480s: an irregular triangle, round towers at two corners but a bastion at the point, a continuous corridor inside and many gun positions, but it still had a donjon and machicolations.<sup>42</sup> Southern Europe offers the clearest

<sup>42</sup> Verdier 1939, 282-316; Hale 1983, 9, 16. Other examples from these decades include Brancaleone (Ravenna, 1457-1470), Volterra (Pisa) and Imola (Bologna, both 1472), San Leo (Rimini,

examples of what would become the solution. Here, the threat of Ottoman artillery had been well recognised since the fall of Constantinople in 1453 and was continuous. Dubrovnik's defences were regularly updated over many decades (Fig. 17) – the older Minčeta tower stands inside casemates with walls six metres

1477), Brolio (Arezzo, 1484), and Sarzana (1487) and Sarzanello (1493, La Spezia).



Fig. 20. Navarrenx (Pyrénées Atlantiques), bastion fortress built by Italian engineer 1530s. Photo P. Purton.

thick built from 1461, numerous gun positions, a wide ditch and outworks.<sup>43</sup> Near Perpignan, now in southern France but then in Aragon, stands the fortress of Salses (Fig. 18) – built from 1497 to oppose the French, this is quadrangular and low lying with bastions – though not pentagonal – for guns, very thick walls, a caponier, outworks: it is a genuine forerunner of later designs despite clinging onto a tall donjon for the governor.<sup>44</sup>

In 1500, there were fortresses with pentagonal bastions attached, but none were yet integrated into an overall design. The nearest probably are the works to strengthen Rhodes after the failed Ottoman siege of 1480 (Fig. 19). The bastions of Rhodes are of different shapes and sizes, and as important perhaps were the steps to create outworks shielding the medieval walls, the thickening of those walls, an enormous ditch and the creation of gun platforms to keep an enemy at distance.<sup>45</sup>

Not yet a complete early modern fortress, but recognisably closer.

The 16<sup>th</sup> century saw the introduction of the modern fortress with bastions. Italian engineers in particular were hired all over Europe to plan modern fortresses with bastion systems as at Navarrenx (Fig. 20) built in the Pyrenees by an engineer from Verona in the 1530s, and in the 2<sup>nd</sup> half of the 17<sup>th</sup> century also in Peitz in Brandenburg by Francesco Chiamella around 1560, and later – 1590 – Rocco Conte di Linari at Küstrin (Kostrzyn).

There is much more detail to add and many more questions to pose and to answer, this paper has merely proposed the key turning points over a period of almost two centuries in which artillery, and fortifications, were transformed forever from the medieval to the early modern world.

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<sup>43</sup> Santoro 1994, 33-38; Deanović 1979, 275-290; Karaman 2003.

<sup>44</sup> Bayrou et al. 1998, passim.

<sup>45</sup> Gabriel 1921, passim; Migos 1980, passim; Kollias 1998, passim; Spiteri 2001.

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