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Term Paper:
Early Modern Fortress Design

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If the medieval age was a time of feudal lords and their castles, the picturesque landmarks Europe is known for today, the Early Modern Period brought with it a very different meaning to fortification. The introduction of gunpowder to Europe was one of, if not the most important, developments in the late Middle Ages. Gunpowder revolutionized the offensive side of warfare, which in turn shaped the defensive (Iakovlev, 31). This paper will examine the fortresses as they appeared in the Early Modern times, discussing their elements and showing how artillery and musketry shaped each aspect.

The first time cannon were explicitly mentioned in historical documents was in 1324, and by 1377 the Duke of Burgundy was employing 140 cannon, some capable of firing a 90 kg stone shot (Hogg 1975, 28). These early models were not enough of a danger to cause an immediate change to the way fortifications were built. Early gunpowder was slow to ignite and the cannon themselves were heavy and difficult to transport. However, once the new "grained" gunpowder was invented in 1425, fortress engineers had a new problem on their hands. With respect to the old castle walls, Hogg states that "the cannon now made nonsense of these defenses … the greater the height, the better target indeed, as more masonry was liable to collapse after a breach was made." (ibid)

At first, attempts were made to modify existing castles to resist these novel artillery attacks. One of the first was Ravenscraig, built in 1460, with many following its general design. These new castles had immensely thick walls, with

those of the Salses castle in France 70 feet thick (Hogg 1975, 31). Not surprisingly, their height decreased and the tower diameters greatly increased, to support defensive artillery. They usually had a central tower surrounded by half-round bays, bearing a resemblance to short towers. Deal Castle, a part of King Henry VIII's line of coast defense in 1539, is another good example of these improved fortifications (Figure 1). Cannon can be seen on its outer ring of casemates, with the ability to swivel and thus provide a wide arc of fire. Guns could be mounted on the inner casemates and the central tower as well, providing additional protection and making the central tower self-defensible (ibid). However, although such castles were superior to their medieval counterparts in the age of artillery, they were only an attempt to reconcile the old and the new. The defense system would have to be reinvented in order to progress.

In the fifteenth century, Italian states were not only fighting amongst themselves, they were also used as pawns in the struggle between France, Spain and Austria. The states were also rich enough to devote large amounts of money to fortifications and fund engineers responsible for their design (Hogg 1981, 110). Duffy argues that it was Italian engineers who first introduced the bastion system, a radically new approach to fortification (Duffy 1985, 1). Other sources say otherwise, proposing that bastions were a product of a natural technological evolution (Iakovlev, 35). And although the system kept changing throughout the Early Modern times, the basic parts of most fortresses are very similar and are summed up well in Figures 2 and 3 (from the top and from the side, respectively). The town stood to the left in Figure 2, with an earthen massif and a series of ditches protecting it. Soldiers and

cannon resided on level planes, called the banquette and the terreplein. They were protected from enemy fire behind a raised mound of earth, called the parapet. A steep slope, or scarp, separated the parapet from the ditch below. The ditch was used to slow down the besiegers through either flooding or as an obstacle for artillery (Duffy 1975, 60). A scaled down and somewhat inverted version of the inner scarp was put in front of the ditch, called the covered way. This was where the front line musketeers were positioned. A wooden fence, or palisade, at the parapet of the covered way ensured a difficult entry for the besiegers. Finally, a slope going into the countryside, the glacis, acted as a cover from fire to everything behind it and forced attackers to dig trenches in order to progress, making their job more difficult (ibid, 62). Although these elements do resemble the walls and moats of medieval castles, their dimensions, construction and purpose are very different. These major parts are going to be examined in more detail to show just how much gunpowder-based warfare influenced design.

The bastion, a key defensive structure, was introduced as early as 1433 in fortifications built by Filippo Brunelleschi at Pisa (Hogg 1981, 100). It is shown in detail in Figure 3. The bastion replaced the tower, providing a more spacious area needed for cannon. The bastion arrangements denied the attacker any position from which he could use enfilade fire (fire along the longest horizontal) by eliminating long axes. Shaped like a partial rhombus protruding out of the wall, it was to provide protection to the walls on each side as well as the adjacent bastions (ibid). Although the basic round tower could work well, it ultimately left dead ground in its front (refer to Figure 4). Designing bastions required good

understanding and careful use of geometry, to ensure as little wasted space as possible. Complex diagrams had to be drawn out beforehand in order to plan out the site (Hogg 1975, 54). The bastion's advantage was apparent: firing along the length of a wall could kill or disable several men, while firing frontally would only cause one casualty per shot. As Hogg puts it, "This conjunction of bastion face and enfilading fire governed the science of fortification for the next four centuries." (Hogg 1981, 101)

On the inner parts of a fortress, the terrain rose about a dozen feet to the terreplein, the platform for mounting artillery. It was usually around 45 feet wide, taking into account the size of a cannon, space it needed for recoil and service as well as space reserved for two ammunition carts. The banquette, firing-step for infantrymen, was normally between four and five feet wide, supporting two ranks of musketeers. The parapet protecting them was the most vital part of this arrangement, most exposed to enemy fire. It was usually formed of soft, stoneless and well-beaten earth. At about eighteen feet thick, it was proof against all the cannon of the time. (Duffy 1975, 47-48) The cannon would either rise over the parapet due to high carriages they were placed on, or poke through embrasures, or gun ports, in the parapet (ibid, 49). The rampart could have different foundations depending on the ground below. Firm ground required no additional support, while a timber framework was used in soft ground to prevent the structure from sinking in. A marshy site required additional support, with piles being driven in first and the wooden grating positioned on their heads. Oak and fir actually became harder after long soaking, meaning the engineer did not have to worry

about the structure rotting. Figure 5 shows the different types of foundations. Rock foundations, while providing the firmest base, would require many pronounced changes in levels and were thus harder to work on (ibid, 40-41).

The scarp was covered with a retaining masonry wall called the revetment. The sharp slope of the revetment was used for the sake of stability, and ranged from one-fifth of the height to the near-vertical one-tenth. It served to maintain the contour of the scarp and as an additional defense against the cannon shots. Some engineers chose to have a "demi-revetment", in which masonry only covered the lower half of the scarp. This unquestionably made it easier to scale the fortifications, but it also presented some advantages (Duffy 1975, 51). It was considerably cheaper, since most of the masonry was covered from cannon shots by the counterscarp (Figure 2). Additionally, the "step" of the demi-revetment could be utilized as a narrow sentry walk (ibid).

Strangely enough, there was little freedom when designing the ditch, as its depth and width largely depended on the volume of soil required to build the ramparts. However, it was generally accepted that wet ditches were wide and dry ditches narrow in order to be useful. Duffy points out that most effective ditches were those that combined elements of both, with a cuvette, a V-sectioned trench running throughout the ditch to drain any excess water and the ability to flood the ditch via special mechanisms called 'water maneouvres' (Duffy 1975, 60). The ditch went around the entire rampart and it also was where detached works were placed.

The covered way (in the sense that it was covered from view or fire) was first suggested by Nicolas Tartaglia in 1556, who reasoned that it would be advantageous to have a ledge in front of the ditch and behind the glacis on which defenders could patrol and shoot at the enemy (Hogg 1981, 111). On the covered way, the ground was about ten yards wide, enough for the movements of defending troops but not for the besieger's cannon to be placed on. Because of the frequent movement of men on this structure, it soon became necessary to support the slope going into the ditch with a revetment of its own, known as the counterscarp (ibid, 112). The covered way was also protected against infantry assault by a palisade. After unsuccessful Spanish and Austrian palisades that were set on the very top of the covered way, Vauban, one of the most distinguished fortress engineers of the time, modified the design so that the stakes rose the full height of the parapet, protruding by only 9 inches (Duffy 1975, 61). There were gaps of about three inches between the stakes through which muskets could be inserted. It was ensured that the minimum angle between any two branches of the covered way was 100°, allowing the musketeers to fire straight ahead with no danger to their comrades (ibid). Outside of the covered way, the glacis sloped down with a gradient between 1:16 and 1:40. The slope also concealed revetments from view, forcing attackers to bring their guns to the very edge of the ditch (ibid, 62).

In addition to the above-mentioned elements, fortresses often used outworks in their ditches, which greatly varied in their shape and extravagance. Figure 6 is a good representation of how far military authors and engineers went with their imaginary designs. Of these, the most common was the ravelin, an arrow-shaped

bank of earth sitting between two bastions and providing extra protection. It had a parapet along the two faces angled towards the enemy and a simple face on the back. Building a system of bastions and ravelins ensured that the fortification had no straight wall and instead was a series of arrow-shaped structures across the whole front (Hogg 1981 115). For close-range defense, various smaller structures called tenailles were built, sheltering troops when they were assembling for sorties and concealing the base of the main rampart from artillery fire (Duffy 1975, 65). Where it was necessary to strengthen a weak section of the fortress, more fortified enclosures, called hornworks, were used. They consisted of two half-bastions with a ravelin in the middle (Hogg 1981, 125). Vauban utilized these at Ypres, Lille and Tournai and was very pleased. (Duffy 1975, 65) Figures 7a and 7b present the different kinds of outworks.

All these elements could be employed to construct so-called citadels, immensely strong four or five-bastioned works adjoining the main fortress. A prime example would be the citadel at Antwerp designed by d'Urbino in 1567. Antwerp was considered to be a marvel of its time and much of the theory and practice that followed was based on d'Urbino's design (Figure 8). The complicated mathematical calculations and the resulting polygonal shape can clearly be seen from its geometrical analysis. It was here that the parapet and the terreplein have been utilized effectively for the first time. Antwerp stood for almost three centuries, withstanding a powerful siege as late as 1832 (Hogg 1981, 114)

From the ramparts to the glacis, from small-scale tenailles to large-scale hornworks, from regular fortifications to heavily guarded citadels it can be observed how much of an effect the cannon and the musket had. The structures were made to both defend against gunpowder weapons and to utilize them. These new fortifications were expensive projects, undertaken by state governments rather than feudal lords and manned by a large military force. They required a great deal of skill in mathematics, as well as technical knowledge, from the engineer (Duffy 1975, 29). One letter concerning a fortress design provides good insight into the mood of the time: “We do not live in a reign which is content with little things. With due regard to proportion, it is impossible to imagine anything which can be too great.” (Duffy 1985, 6) Even if they were not as scenic and memorable as their medieval predecessors, these architectural achievements were a technological marvel of the early modern times, readily accepted and employed throughout Europe.

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