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Non-destructive analysis of concrete from Northwest Bohemia defence structure built in 1937

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Abstract. This contribution deals with the experimental investigation of compressive strength of over 80 years old reinforced concrete structure. In various regions of the Czech Republic we still have a large system of defence structures built in 1930th as the reaction for political development in Germany and the potential risk of war conflict. In the article the results of non-destructive analysis of concrete applied to a defence structure in northwest Bohemian region are presented. In 1937, the compressive strength measured destructively on test samples achieved 41.5 MPa. The non-destructive analysis was performed mainly in the interior part – roof and walls and also in one location in the exterior. The compressive strength measured by Schmidt hammer achieved 68.5 MPa in the exterior part, 53.2 MPa for roof in the interior part and the wall in the interior achieved between 49.4 MPa and 58.5 MPa. Performed non-destructive testing provides the approximate information about the quality of concrete without damaging the historical structure.

Introduction

In the conditions of political situation and development in Europe and especially in Germany during the 3rd decade of last century several defence military systems and structures were built in various regions across countries. The former Czechoslovakia government, in line with the French experts´ knowledge and experiences, decided to build an extensive system of defence reinforced concrete bunkers. The main burden of defence was based on the system of lightweight reinforced concrete bunkers called "ŘOP no.37" designed for 3 to 6 soldiers. The number 37 means year 1937 when these bunker were approved for widespread construction. The defence lines were planned and build especially in borders area with Germany. After the occupation of Austria this system was extended to the southern border. Over the more than nine thousands of bunkers were built and about over four thousands have been preserved to nowadays. Lastly, there is a growing interest in the preservation and further development of these by many persons, communities or companies.

Description of the analysed bunker. The defence structure analysed in this contribution is the type no. 37 with full designation C27/52a/A-140Z, see the photography on Fig. 1. "C27" means the line section of the defence system in Czechoslovakia, in this case Lišany, while "52a" is the number of bunker in line. The letter "A" means the type of bunker when this is the most widespread type of light defence structure. And the number "140" indicates the angle of shots in degrees (the used degree of shots varies between 120° and 220°) [2]. This type was

originally designed for the side firing of two machine guns on right-hand and left-hand side. The crew consisted of seven soldiers. Investigated bunker is situated on the right bank of the river Ohře in cadastral area of Mradice. Fig. 2 shows the horizontal cross-section of the described bunker, while the Fig. 2 shows the photography of the bunker in-situ. The entrance stairs are covered by thin concrete wall around (marked with thin line). The photography on Fig. 2 also shows this technical solution. The reason for this precaution is to avoid the effect of floods from the river Ohře. The entrance is also protected by a machine gun. The fumes after firing were evacuated by hand operating fan.

The letter "Z" at the end of type designation means, that this specific bunker is "strengthened" to have higher ballistic resistance. The front wall has a thickness of 1200 mm, while the ordinary, non-strengthened bunkers have front walls with thickness of 800 mm.

Fig. 1: Photography of analysed bunker no 37 (C27/52a/A-140Z).

The front part, exposed to expected enemy´s attack, was protected by hand-placed rubble that also worked as camouflage. The rest of this wall can be seen on the left side of bunker on Fig. 1 and it is situated in a place of a growing tree.

It is necessary to mention that the bunkers of no. 37 were not intended for the crew´s long stay. The absence of any facilities confirms this statement. The soldiers used to stay inside only for the necessary time during the expected action of enemy. Within the fortification system built before the Second World War, we can also find larger better equipped and fortified bunkers or artillery fortress with higher ballistic resistance and designed for long stay of soldiers.

Experimental investigation. The quality of concrete from these historical bunkers means the main topic of this contribution. The non-destructive testing by Schmidt hammer [1] was used, with respect to the historical value of investigated structure. Fig. 1 shows the location of measurements performed on vertical structures – walls. There were five places in the interior part (marked as "I") and one location in exterior part (marked as "E").

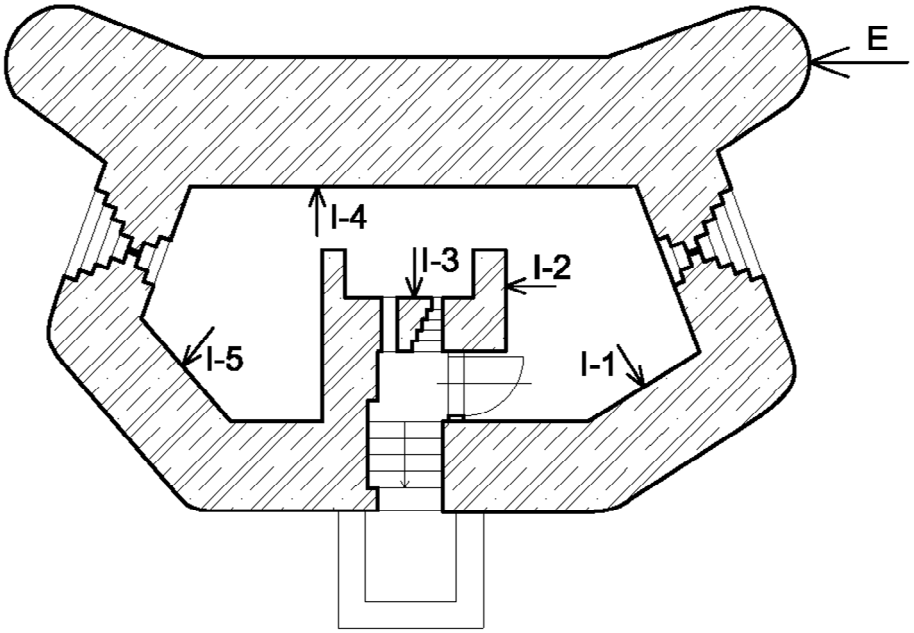

Fig. 2: A cross-section of bunker no 37 (C27/52a/A-140Z) with location of measurements.

Fig. 3: Different quality of concrete.

Fig. 4: Remains of the original plaster.

The properties of concrete achieve different characteristics while investigated in various locations – for example the denser concrete can be find in the lower part of walls (see Fig. 3). Therefore the measurement took place on three locations – in the top of the wall, in the centre and in the contact with the floor. Totally 45 measurements were performed on each interior locations. From horizontal structures the quality of roof from interior part was also investigated – totally over 50 measurements were performed. The exterior part has specific issue that limits using of Schmidt hammer. After the casting and unmoulding of formwork a slim layers of coloured plaster were additionally applied on the massive reinforced concrete structure. These plasters worked as a camouflage shield and in large number of bunkers have been preserved. In investigated bunker, remains of original plasters were identified in the contact of walls and earth (see Fig. 4). From this reason it is not possible to performed non-destructive testing by Schmidt´s hammer without removing original plasters. From this reason only one place from exterior side was analysed (marked as “E” on Fig. 1) where the original plasters has not preserved.

Results. From the visual point of view the concrete showed different qualities especially due to the used way of compaction. In 1930´s especially the manual compaction was used. The roof showed homogenous surface without caverns or similar imperfections. The surface layer

of walls achieved various qualities. Most of the places showed homogenous surface of high quality. On the other hand there were locations with insufficiently compacted concrete, in extreme case with uncovered steel reinforcement. The significant differences in the quality of concrete were confirmed in study performed by Pazderka et. al. [3] where the bunker R-S74 was studied and the laboratory analysis showed that the bunker's concrete is very inhomogeneous and it has very different properties in terms of its permeability.
The table 1 summarizes average values of performed Schmidt´s hammer measurements including the standard deviation. During solving the NAKI II project an original report from strength test performed in 1937 by Klokner Institute was found, therefore the information of original strength was available. The strength in 1937 was calculated based on compressive test of cube specimens with dimensions 200×200×200 mm and achieved 41.5 MPa.

Table 1: Results of measurements performed with Schmidt hammer.

Location	Schmidt [MPa]	Standard deviation [MPa]
Exterior – E	68.5	± 2.7
Interior – I-1	57.8	± 5.2
Interior – I-2	52.9	± 5.4
Interior – I-3	58.4	± 5.3
Interior – I-4	58.5	± 4.8
Interior – I-5	49.4	± 4.7
Interior – roof	53.2	± 4.4
Strength calculated in 1937	41.5	N/A

Conclusions

The strength investigated by Schmidt hammer oscillates between 49.4 MPa and 68.5 MPa. The highest strength characterizes the exterior part, while the interior part reaches balanced values. The Schmidt´s hammer provided the tentative compressive strength of concrete, with carbonation consideration especially for the older concrete, which is the case under study. This process can cause the increase of strength in the surface layer. The concrete showed different quality especially caused by the used process of compaction.

Acknowledgement

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