Protection of church buildings in mining areas

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Marian KAWULOK
Head of the Institute's Division
Building Research Institute
Gliwice, Poland

Marian Kawulok, born 1941, received his civil engineering degree from Silesian Technical University in 1964 and PhD in 1980. He is currently head of Division of Building Research Institute in Gliwice and lecturing on Silesian Technical University.

Summary

Church buildings erected as traditional structure arrangements with brick walls and shell vaults are characterised by low spatial stiffness and low resistance to tensile forces. Therefore, they are especially sensitive to all ground movements, including land deformations caused by underground mining activity. The protection of church buildings is an important technical and social -economic problem in the Silesian Mine Basin in the south of Poland, where intensive underground mining is still conducted on large scale. Generals rules of the assessment of mining activity on church buildings and structural measures of their protection are discussed in the paper. Examples of strengthening and other solutions considering the protection of the existing buildings subjected to mining influence are presented, together with a short analysis of their efficiency.

Key words: mining areas, church buildings, mining trough, structural measures of protection

1. Impact of mine-induced subsidence trough on buildings

Land deformations which result from underground excavation activities, are manifested on the surface mostly in the form of regular subsidence trough (Fig. 1).

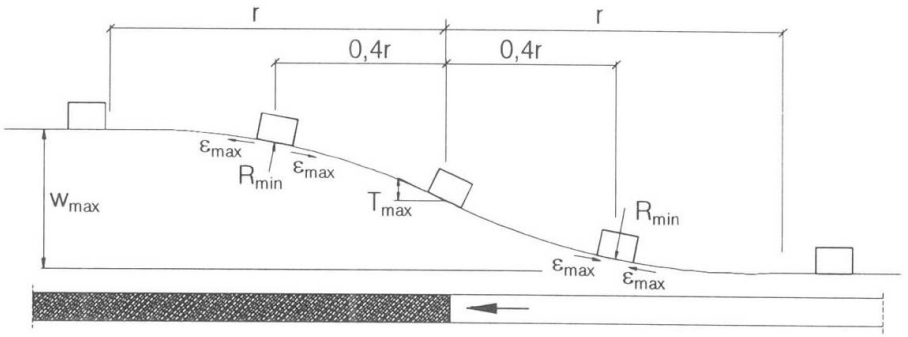

Fig.1. Typical layout of a building situated in mine-induced subsidence trough, r- radius of mining impact range.

The shape of the subsidence trough may be described by the following indices, whose rate is determined by the geological and mining conditions pervading in given areas [1]: vertical displacement (subsidence) w, horizontal displacement u, tilt T, curvature K (or curvature radius R = 1/K) and horizontal strains ε.

2. Principles of church buildings protection

The diagram of the impact of convex subsidence trough upon the diagonal bearing elements of the discussed structures is illustrated in Fig. 2. Following the horizontal displacement of the foundations of pillars and walls due to the impact of horizontal strains, the supports at the vault abutments level are also displaced (Fig. 2 a). The impact of curvature radius evokes analogous results as to the quality of structure condition. Following the rotation of the supports of the structure, its abutments may also be horizontally displaced (Fig. 2 b). In both cases, the values of initial compressive stresses are reduced in all structural elements, which poses particular hazards to arches and vaults. Nevertheless, the most disadvantageous effect is produced when the building is set diagonally in the subsidence trough (Fig. 2 c), because its corners subside at different rates ($w_1 \neq w_2 \neq w_3 \neq w_4$). Due to low spatial stiffness characterising traditionally constructed church buildings, such impact results in considerable hazards to the resistance and stability of church vaults.

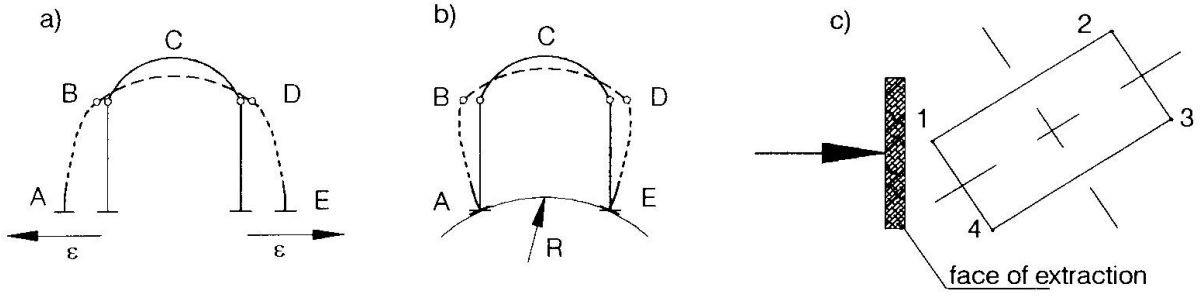

Fig. 2 Diagrams of the impact of subsidence trough on buildings.

The rudiments of protecting the bearing elements of church buildings located in mine - induced subsidence trough involve the limitation or elimination of the displacement occurring at the foundations level A-E , as well as at the level of vault abutments B-D (Fig. 2 a, b). On principle, if the foundations are strengthened, the detrimental impact of horizontal strains on the whole bearing structure of a building is eliminated. On the other hand, if the structure is braced at the B-D level, the impact of ground deformations on the structural elements of the vaults, which are particularly vulnerable, is theoretically excluded. However, it should be emphasised that to reduce the detrimental impact of the mining works conducted diagonally, the strengthening elements should have a truss structure, as a rigid system in the plane. This is particularly important to the bracing at the vault abutment level, plane B-D. Hogging or sagging ground curvature evokes uneven subsidence of the building walls. It is only possible to protect the walls against bending by bracing at the vault abutment level, or, if such strengthening is feasible, at the intermediate levels.

The paper presents examples refer to the protecton of three aisle church buildings, whose bearing structures consist of the exterior brick walls and interior system of pillars, separating a higher central nave. Brick arches are supported by the walls and pillars. The space between the arches is filled with gypsum shell in the form of a vault. In plane view, these buildings have the shape of a cross, with different dimensions. They also differ in their bodily shape, structural solutions and the geological and mining conditions of their foundations.

Given examples allow to say that preventive treatment of church buildings in mining areas includes the methods which usually provide for the safe usability of churches, but do not exclude the possibility of the occurrence of even major damages, as such structures are characterised by low resistance to mine- induced ground deformations.