



Investigation of discrepancy between tuff used as building stones in historical and modern buildings in western Turkey



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HIGHLIGHTS

- This study presents a case study on characterizing tuffs for building stone use.
- Durability properties of tuffs may change in a short distance in same tuff.
- Static durability index has not given reliable results for the studied tuff.
- Mineralogy of tuffs are found to affect their durability significantly.

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ABSTRACT

Tuffs located around the town of Alaçatı, Turkey have been used in building construction for many years in the past. Recently, based on the efforts of the local government to develop a unique identity for the town, this practice is re-initiated. After about five years from construction, tuff used in newly constructed buildings started to show signs of deterioration. Even though tuff used in recent and older buildings in the town appeared to be the same to the naked eye, a similar deterioration has not been observed in the buildings constructed in the past (some are more than 100 years old). A previous research study has documented the suitability of tuff used in new constructions but the reasons for the discrepancy between the tuffs used in construction of the older and newer buildings has not been previously investigated. In this study the different field performances of tuffs used for historical and modern buildings were investigated against deterioration in the same environment based on the material properties and their durability. This comparison showed that the mineralogical composition and amount of clay contents of the tuffs were one of the major factors resulting in difference in deterioration and durability rates of the tuffs used in building construction within the region.

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1. Introduction

Alaçatı town is one of the well-known small touristic areas along the coastline located about 70 km west of the City of Izmir in Turkey. It is a small town locally famous for its historic and modern buildings with exterior surfaces constructed with tuff, as tuff is one of the geological characteristics of the region. Tuff is a rock composed of compacted volcanic ash with particles varying in size from fine sand to coarse gravel. The presence of tuff has previously been an interest to geologists and several studies have been

conducted in the region to characterize the rock and the stratigraphic sequence of the geological units [1–4].

In 2005, to preserve the historical appearance, the Alaçatı municipality has passed a resolution making the use of tuff compulsory in construction of the exterior facing of all new buildings and garden walls [4]. As a result, in the near past, a detailed study has been conducted in the area to characterize the tuff as a building stone in these new constructions [4]. The results of that recent study identified tuff as poorly suited for construction because of its poor durability. These findings did not come as a surprise to the owners and contractors of the newly constructed buildings because tuff used in these structures have been deteriorating at a fast rate within five years after construction. However, tuff has been used in this region as a building stone for decades. The walls of the homes, as old as 100 years, constructed with tuff can still be

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seen intact in parts of Alaçatı. Beside the old houses, the town has an old church constructed primarily using building stones from tuff in 1838 and three wind mills built more than 100 years ago (Fig. 1).

This research is performed to investigate the discrepancy between the durability of the tuffs used in modern and older buildings. Field observations revealed that the buildings constructed within the last decade or so (i.e., referred herein as modern construction) showed crumbling, flaking, and spalling types of deterioration [4] but the older buildings (i.e., referred to buildings more than 100 years old) only showed crumbling type of deterioration although all of the buildings constructed in the region have been exposed to the same environmental conditions since construction (Fig. 2). During the field observations there have been no records of construction defects both in the historical and modern building walls that caused visible cracking etc. as mentioned by other researchers [5]. Besides the deterioration, when compared, tuff samples collected from old and modern buildings showed very similar physical properties in terms of texture and color and it is difficult to macroscopically tell them apart from each other. During the field investigations, an abandoned tuff quarry was discovered.

The discovered area is approximately 3 km west of the existing quarry that is currently used to produce the tuff for modern construction (Fig. 3) and is located within a private property surrounded by single-family homes. With permission, rock samples were collected from this quarry and local residents were interviewed. Based on the age of the historical abandoned structures in the town, local information, and the lack of use of tuff in the modern construction until 2005, it is estimated that the quarry was abandoned more than 100 years ago or so. In this study, this area is referred to as abandoned quarry.

Based on extensive field investigation, it is determined that there is only one abandoned quarry located in this region. This is also supported by the local information that the discovered abandoned quarry was the source of the tuff used in older (prior to 2005) buildings. Additionally, this finding was confirmed at the beginning of this study by comparing the mineralogical properties

and chemical compositions of tuffs obtained from the surface of the historical buildings and from the abandoned quarry.

Although the observed durability of the tuffs from the historical and modern buildings were very different in the field, when the samples were evaluated macroscopically they appeared to be very similar. Therefore, to investigate the discrepancy, samples were collected from the abandoned quarry (source of the tuff used in historical buildings) and were evaluated in this study in great detail. The results were then compared with the previous evaluation of the tuff collected from the existing quarry (source of the tuff used in modern buildings) [4].

2. Geological settings

The area investigated as part of this study is located in the eastern part of Karaburun Peninsula in Turkey and has complex geology (Fig. 4). The rock units of the area have been previously determined to be predominantly composed of middle-upper Triassic dolomitic – limestone. These units unconformably overlie early Miocene lacustrine-terrestrial sediments, which were determined to be approximately 215-m-thick ranging in size from bottom-up as pebblestone to primarily claystone – argillaceous limestone – marl intercalation, [6,7]. The lacustrine-terrestrial sediments gradually regress to volcanoclastic succession of Armağandağ volcanics [1,2]. The volcanoclastic succession, which covers an area of about 200 km² around Alaçatı, is mainly composed of white-colored pumice-and-ash-fall deposits (a.k.a. tuff deposits). These deposits are overlain by lithic-rich ignimbrites, which are overlain by block and ash-flow-deposits. The sedimentary and volcanoclastic successions were cut and covered by 17.3 Ma aged andesitic lava domes and dikes of Armağandağ volcanics [2] (Fig. 4).

3. Climatic conditions within the study area

Stones, in general, are highly durable natural materials as they have been one of the most commonly selected construction



Fig. 1. Examples of historical buildings constructed in Alaçatı with tuff: (a) historical house, (b and d) historical church that was built in 1838; and (c) abandoned historical wind mills.

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