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Analysis of the evolution of the instability process of a coastal cavern

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This work concerns the study performed for the interpretation of the potential failure mechanism of a large natural cavern, which is located along the rocky cliffs of Polignano a Mare town (Apulia, Southern Italy) under an intensely urbanised area. This cavern, which is located at the sea level, was formed due to an intense process of salt and wave erosion, mainly acting during sea storms, within a rock mass formed of a lower stratified limestone mass and an upper soft calcarenite mass. Therefore, the influence of the climatic factors and of the upward erosion process within the cavern has been specifically investigated. At present, the thickness of the cave roof, which has a dome shape, is less than 10 metres in the centre and several buildings are founded on the ground surface above. In 2006 a large calcarenite block, of about 1.5 m diameter, fell down from the roof of the cavern and afterwards field and laboratory investigations as well as both simple analytical methods and elasto-plastic numerical modelling were carried out in order to assess the current state of the roof and to interpret the effects of the potential evolution of the inner erosion and of the local failure processes of the cave. As such, a detailed geo-structural survey has firstly been carried out, together with laboratory and in-situ testing for the geomechanical characterisation of the rock materials and of the corresponding joints. An analysis of the sea storms occurred within the observation period has also been performed by considering daily rainfall and wind data. The rate of erosion has been measured by means of special nets installed at the sea level to collect the material falling down from the roof and the corresponding measurements, which lasted for about one year, indicate an erosion rate of at least 0.005 m3/month. A structural monitoring system, including extensometers and joint-meters, was also installed in several points of the cave in order to measure eventual block displacements within the cavern and the results show some correlations of the logged data with the occurrence of sea storms and in general with the weather factors. The results of both simplified analytical methods and numerical analysis show that the cave is at present stable. Also, numerical modelling was aimed at defining the conditions under which general failure of the cave might occur. In particular, sensitivity analyses have been carried out to assess the influence of specific factors, as the progressive reduction of the roof thickness due to erosion or the gradual reduction of the strength properties of the calcarenite due to weathering processes.